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A Working Model of a Filtration System

By Harold J. Abrahams

THE preparation of potable water for municipal use is a subject which touches in a vital way the lives of all citizens. All too often, however, the only citizens, young or old, who can claim some understanding of the technique by which water is rendered potable are those who have had the process explained to them either in chemistry, hygiene, or general science classes. This state of affairs necessarily places a limit upon the number of persons with such knowledge to an extent incommensurate with its importance. An exhibit which, by its appeal to the eye, demonstrates in a vivid manner the main points in the treatment of municipal water supplies should serve a very useful purpose both as a supplement to the regular class work in the chemistry of water and as a lesson in civics.

The model described here (Figs. 1 and 2) makes its appeal to the eye, not only by representing the locale of a water filtration plant, but by showing flowing water, highly charged with impurities, actually passing through the three stages of purification—coagulation, sedimentation and filtration.

A three by five foot table was chosen as suitable support for the model. The river, reservoir, alum house, coagulating basin, settling basin, and filter were placed in their respective positions, each at the correct height with respect to the other. A wooden framework of

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Fig. 1. Model Filtration System

uprights and struts was constructed around these vessels, and burlap stretched and tacked over the framework. Approximately one inch of plaster of paris was then spread over the burlap. The plastered burlap was designed with a profile that would give a fair representation of the land area forming the site of a water filtration plant. Thus the reservoir was located on an eminence and the river at a low level. The main areas of the model were painted a shade of green to simulate grass. Gloss was prevented by a light sprinkling of dry plaster before the final coat of paint, thus producing a roughening of the surface. A small area was shaped and painted to represent rocky

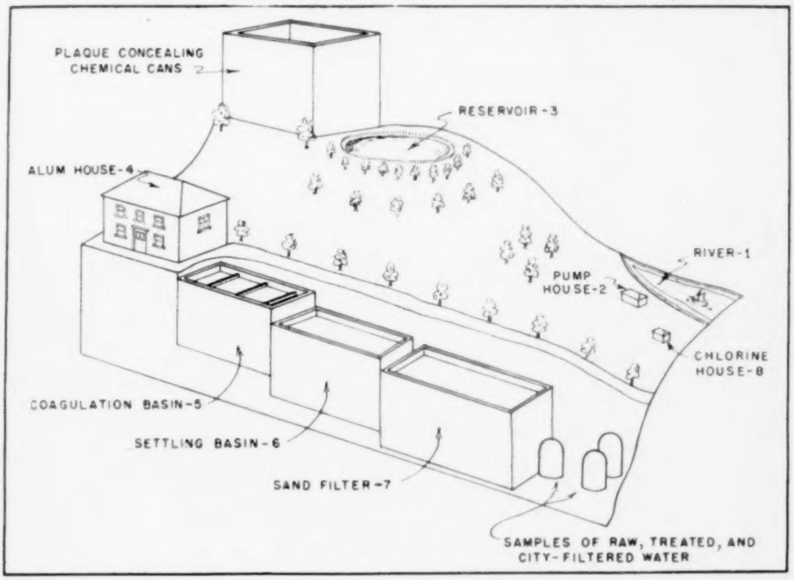

FIG. 2. Detail of Model

strata to relieve color monotony. Two gray-colored roads were included, each with toy automobiles and trucks. A high-masted sail-boat gave the river a realistic touch. Red, brown, green and yellow trees, made of suitably dyed sponge fastened to match sticks, suggested an autumnal landscape. These trees were mounted in tiny holes drilled into the plaster.

Details of Construction

The river was made of a piece of galvanized iron sheeting, fashioned into a shallow pan, approximately triangular in shape, to represent a

"quarter-section" of a river (Fig. 3). It was painted brown and heavily paraffined. A road, automobiles, trees and a "dummy" pumping station completed this corner of the model.

The reservoir was made of tinned sheet iron, painted brown on the inside and heavily paraffined. It was fitted with intake, output and overflow pipes of the same material. The intake pipe ended in a glass tube, drawn to a capillary, and bent parallel to the bottom of the reservoir (Fig. 4). The plaque, located near the reservoir, carried the title "Model of a Water Filtration System" and concealed two five-pound chemical cans, heavily paraffined and each of which had a short length of copper tubing soldered near the bottom (Fig. 5)

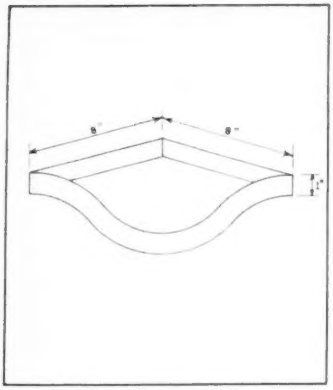

FIG. 3

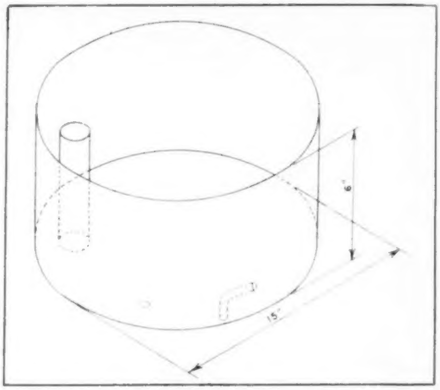

FIG. 4

FIG. 3. Detail of River
FIG. 4. Detail of Reservoir

Each of these tubes had a glass tube ending in a capillary attached to it by means of rubber tubing. The glass capillaries overhung the iron gauze fence of the reservoir in an unobtrusive manner. Screw clamps over the rubber tubing regulated the flow of liquids from these cans, one of which contained a saturated solution of manganous sulfate and the other ammonia water. By use of this apparatus a constant supply of "mud-making" chemicals was dropped into the reservoir, thereby simulating untreated river water. Stirring action for "mud" and water was provided by the capillary jet at the end of the water intake pipe. The entire stratagem, necessary to make the water turbid enough to require treatment and filtration, was quite inconspicuous to the observer.

The source of supply of water for the model was the water pipe of the nearby drinking fountain to which a reducing valve was attached. Despite the evident character of the actual source, however, an attempt was made to create the illusion that the pumping station sent the water from the river to the reservoir.

The alum house was made of balsa wood. Its roof was ornamented with copper sheathing; and it was planned, in other details, to appear rather realistic. In reality, it was only a "shell", consisting of roof and side walls. When lifted up, it disclosed nothing more than a prosaic galvanized iron tank with copper output tube (Fig. 6) which discharged alum solution through two finely drawn glass tubes, into

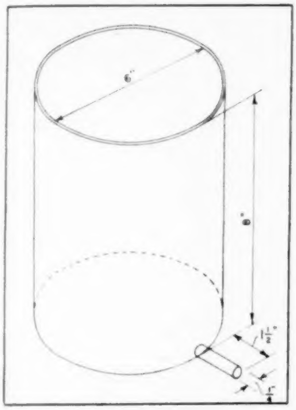

FIG. 5

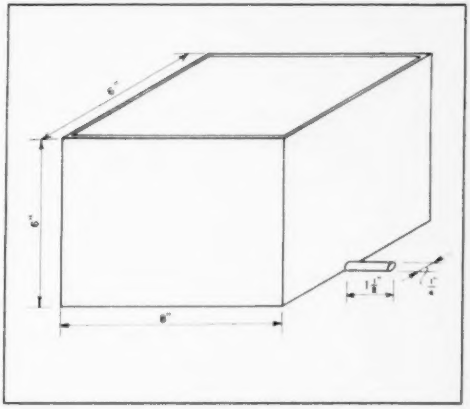

FIG. 6

FIG. 5. Chemical Cans for Producing Turbidity
FIG. 6. Detail of Interior of Alum House

the coagulating basin. The alum solution not only coagulated the manganous hydroxide but the fine jets also produced a stirring action.

A rubber tube led down, under the plaster shell, from the reservoir to the first aquarium, serving as a coagulating basin (Fig. 7), and delivered the turbid water to the latter. This aquarium had two perforations, made with a "biscuit-cutter," on the side adjacent to the alum house. The perforations were fitted with rubber stoppers each of which served as a mounting for one alum solution jet and one turbid jet. This plan was followed to insure thorough mixing of the materials. A perforation on the opposite side of the aquarium was likewise fitted with a two-hole rubber stopper, bearing glass tubes for delivery of the treated water to the next aquarium, acting as the

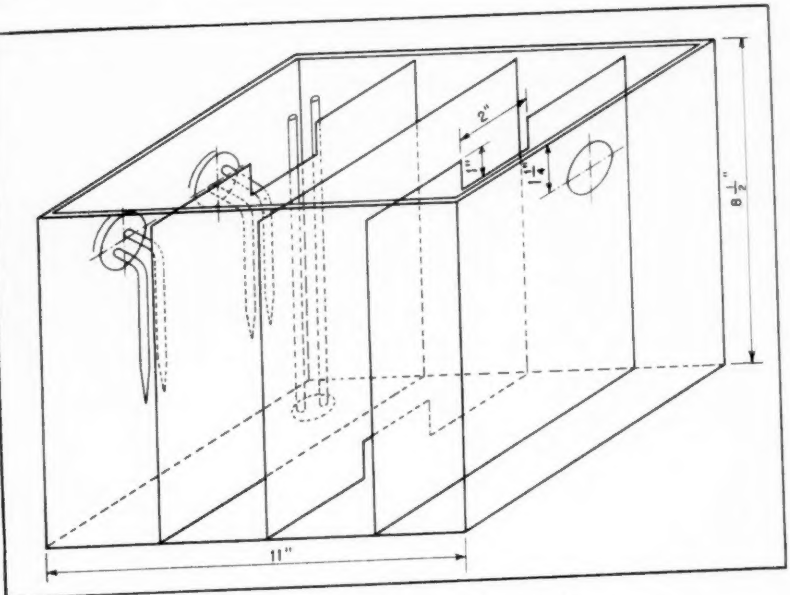

Fig. 7. Detail of Coagulating Basin

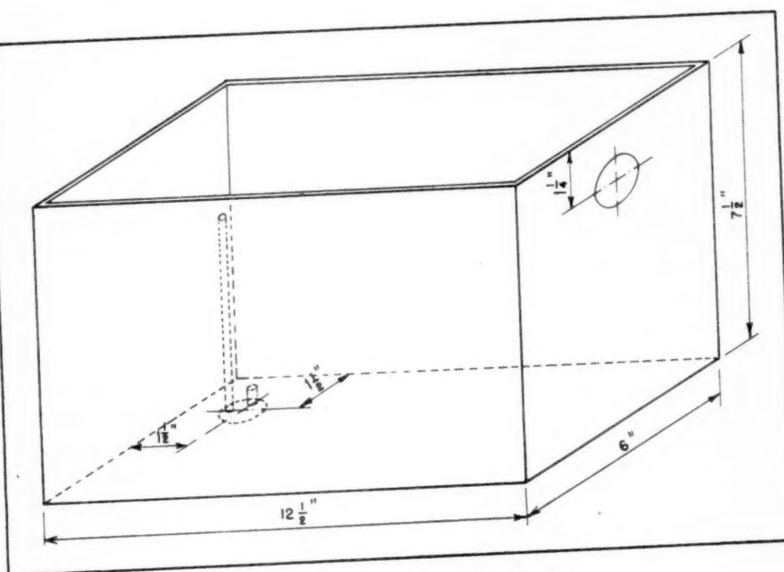

Fig. 8. Detail of Settling Basin

settling basin. The coagulator was also furnished with three notched bakelite "baffle" plates cut from an old radio panel. These were fastened together by means of two glass rods which ran through the three plates near the bottom, one on each side. The rods were made to fit holes drilled through the bakelite by using gaskets cut from rubber tubing. The action of the baffle plates was altogether satisfactory. Close observation easily revealed the fact that the alternating notches, the first and third at the top, and the second at the bottom of the plates, imparted two complete down and up motions to the flowing water. The deliberate loss of time thus suffered was sufficient to permit much coagulation and settling in the first aquarium.

A second aquarium (Fig. 8) served as a settling basin. Instead of delivering the coagulated water into it at the side adjacent to the coagulator, a pair of glass tubes about ten inches long brought the water to the opposite side, that is, the side near the third aquarium (filter). A third glass tube, also about ten inches long, open at the coagulator side, conveyed this water across the settling tank, to the filter. This baffle action provided more time for the mud to settle and prevented it from floating straight across the top of the settling basin. The settling basin was perforated to accommodate a rubber stopper, bearing the long delivery tube which brought the settled water to the filter. No perforation was necessary in the other side, as the settling basin was placed lower than the coagulator, allowing the water to siphon as shown in Fig. 1.

The third aquarium (Fig. 9), somewhat larger than the first and second, had resting on its floor a wooden platform made of thin slats, spaced about one-eighth inch apart. Upon the platform rested a layer of coarse and one of finer gravel to a total height of about one and one-half inches. Over these layers of gravel were placed four layers of increasingly finer sand to a total height of at least four inches. The top layer consisted of grains of a diameter of about 0.3 or 0.4 mm. The iron was extracted from these sands by digesting with warm hydrochloric acid for several days. This prevented the filtrate from taking on an embarrassing yellow tint during the first days of the operation of the model.

All three aquariums had slate bottoms. These were drilled and fitted with rubber stoppers each bearing two glass tubes, to act as overflows, in the event that anything went wrong. In the case of the settling tank, however, one of the glass tubes was cut almost level

with the slate. The tube was fitted with a rubber hose and spring clamp, and was used to remove accumulated mud and to back water into the tank to clean it. The two overflows in the filter were fitted to a pair of semi-tubular brass troughs, running the length of the aquarium. Thus they acted not only as overflows, but represented the troughs actually used in cleaning filters. They were used in the model, once each week, for this purpose. A beaker, placed upon the sand in the filter, prevented spattering of the top layer of sand by the incoming water. The tank was also perforated below the filter level, and fitted with rubber stopper, glass and rubber tubing. This and all other tubing from all overflows ran along the tabletop under the

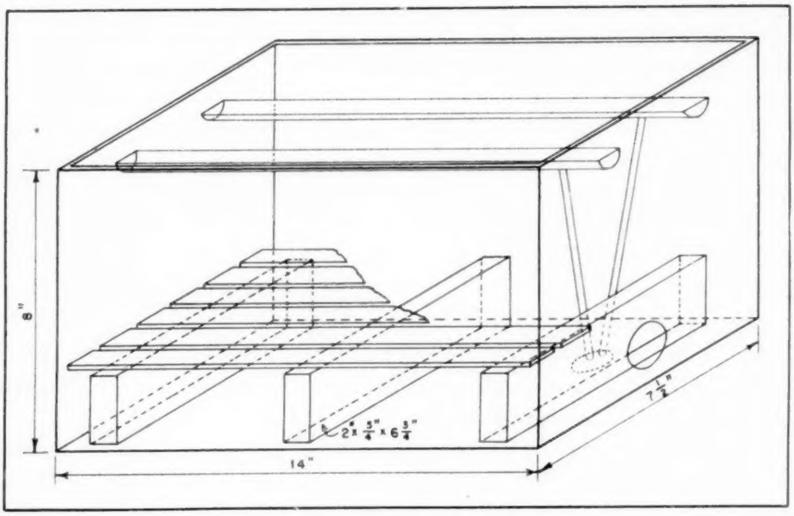

FIG. 9. Detail of Filter

model and discharged filtered and excess water into the nearby drinking-fountain sink, the water pipe of which furnished the water used in operating the model.

Each of the three aquariums had behind it a battery of four flash light bulbs, suitably spaced and mounted in tinned iron reflectors. A storage battery, charged daily, kept these burning brightly. The lighting proved a great help in pointing out the contrast between the filtered and unfiltered water, as well as making more easily visible the action taking place in each tank.

Next to the filter, three inverted museum jars containing samples of water before treatment, after treatment and city-filtered water

were exhibited. White cards behind these facilitated inspection. It was found expedient to use water tinted with a trace of a brown dye to the proper color depth, instead of an actual specimen of water with suspended matter, to avoid the necessity of shaking the sample every few hours.

Small, rectangular blocks of wood with sloping tops simulated a pumping station and a chlorine house. These were only "dummies."

The sides of the model were finished with heavy cardboard, cut to conform with the profile. They were painted brown to create the illusion that the entire system had been cut from and lifted out of the earth.

Explanatory Note

Experience indicates that if an explanatory note is lengthy, it will not be read with care. For this reason, each part of the model was merely identified by number (cut from a calendar) in order of the direction of flow. A brief explanation referring to these numbers, was fastened to the side of the model under the alum house, as follows:

"Water is taken from the

RIVER—1

and is pumped by the machinery in the

PUMP HOUSE—2

to the

RESERVOIR—3.

It is treated with alum (potassium aluminum sulfate*) and then sent on past the

ALUM HOUSE—4

where it meets with lime water and more alum before entering the

COAGULATING BASIN—5.

Here the mud is coagulated by the chemicals added from 4. The mud begins to settle in this basin, which contains baffle plates

* Potassium or ammonium aluminum sulfate is used in a demonstration unit in preference to the commercial filter alum normally employed in the treatment of public water supplies.

to prevent too rapid passage of the water. This allows time for the chemical action to take place. The water now moves on to the

SETTLING BASIN—6

where a large percentage of the chemically treated mud settles. The water and remaining mud now move on to the

SAND FILTER—7

which filters or strains out all the remaining mud. The water is now perfectly clean. It may still contain a small percentage of disease-producing germs. These are destroyed by finally treating the water with chlorine from the

CHLORINE HOUSE—8."

The school automobile shop was kind enough to supply a heavy bronze rail which kept the mischievously curious at a safe distance from the model.

Educational Values

The educational value of the exhibit herein described was entirely gratifying. The method and problems involved in purifying water for a municipality came to life for hundreds of boys and girls. A text book can give only a skeleton, but a working model seems to furnish the "flesh and blood." When the topic of water filtration was reached in class, inspection of the model, which was located in the corridor outside the library, gave an interest and clarity to the subject, otherwise unobtainable except by means of a visit to a city water works. Classes in hygiene and social science also found the exhibit useful. Many students expressed delight with the attractive details, such as the sail boat, toy automobiles and lumber truck. One helpful young lady sewed some one-inch bags which we filled with sand, labelling some "lime" and others "alum" and stacked around the alum house. Many students showed an active interest in the model, both during the process of preparation and after its completion. Some of them spent countless hours spreading plaster, making trees, painting, and so on. Others were found very ready to answer a call to service the model daily with fresh solutions, cleaning out aquariums, exchanging the storage battery, etc.

An interesting student reaction came from still another group of

students, apparently of pedagogical turn of mind, who asked for a comparison of results of their class test upon the subject of water with a similar test administered during previous school terms before the exhibit was set up. Most gratifying was the crowd which gathered each Friday afternoon to see the weekly cleaning of the filter. The filter was drained and water was backed up through the sand. Then the suspended brass mud-drains came into action and a truly interesting scene took place.

Such a model involves much effort in planning, assembling materials and constructing the various parts, but the dividends paid in the form of heightened student interest and real enthusiasm are very generous and make the effort altogether worth while.

Rating and Approval of Public Water Supplies

By R. P. Farrell

FOR a number of years the Tennessee Department of Health has considered the possibility of developing a program for rating and approving public water supplies. Since operation of a water works system is so important in assuring the safety of a supply, particularly one requiring treatment, it was deemed advisable to start a program for the certification of operators in advance of the water supply approval program. Details of the operators certification program were completed during 1939; and although there are only 207 public water supplies in the state, 89 operators secured certificates of competency during the first year.

During 1939, the Public Health Council authorized a program for rating public water supplies in Tennessee. The Commissioner of Public Health immediately advised the Division of Sanitary Engineering of the action of the Council and instructed the Division to work out all details and to put the program into operation. After a study of the various plans and systems of rating water supplies in other states, the problem appeared to be rather discouraging. The following statements from different states and data from others might be of interest here:

A. Found it very difficult to carry on necessary supervisory work to insure that supplies met the requirements, and finally decided that it was too hazardous to permit the use of such signs without adequate supervision.

B. Program in formative stage but in general will include freedom from sanitary defects, regular submission of samples and reports and the certification of operators.

A paper presented on October 21, 1940, at the Kentucky-Tennessee Section Meeting, Lexington, Ky., by R. P. Farrell, Assistant Director, Division of Sanitary Engineering, Tennessee Department of Public Health, Nashville, Tenn.

C. All public buildings and 85 per cent of total population must be served from public supply; samples from all supplies and reports from all treatment plants must be submitted regularly; and quality must meet standards set by U. S. Public Health Service.

D. Program is in formative stage. Do not score or rate but make survey and write report with recommendations which, when complied with, will allow the city to obtain approval.

E. Do not have approval system but have program for certification of operators. No attempt has been made to rate supplies; so much judgment enters into the classification of the safety of water supplies that it appears extremely difficult, if not impossible, to make a fair rating system.

F. Included complete rating system with three separate forms: one for shallow wells, one for deep wells, and a third for surface supplies. The major headings on these forms were pollution hazards, protective measures and quality conditions, with numerous subheads under each. This system appeared to be somewhat similar to an outline of a score system (modified as of September, 1927) in the report of the Committee on Sanitary Scoring, New England Water Works Association.

Although no one of these systems seemed to offer a solution to the problem, numerous ideas were obtained as to what should be included in such a system. In the program of supervision by engineers of the division in past years, it had been customary to consider a water supply from the standpoint of physical equipment, operation and quality. Remembering that a poor workman may do fair work with good tools, and, vice versa, the members of the division set out to develop a rating system based on good physical equipment and good operation, with the expectation that such a program would result in good water.

Bases of the Scoring System

Since it was felt that all items worth including in the design and construction of a water works system should be given credit in the rating system, under the heading of physical equipment, an attempt was made to list each such item. Similarly, all pertinent items were listed under operation and maintenance, and items included under quality standards by the U. S. Public Health Service, with a few additions and modifications, were listed under the heading water quality. The completed list included several hundred items, so that

it was impossible to assign enough points to any single item to make it carry much weight in a score system. From this it was concluded that the number of items must be reduced and that it would be desirable to have a single score system for all types of supplies. To get complete coverage necessitated the inclusion of some items not common to all supplies; but, insofar as possible, item headings which would be common to any water supply were selected.

Starting, then, in logical order, it was found that the first item common to any water supply was source of supply. As many items as possible of those previously listed as subheads under source of supply were then segregated. Other items were classified in a similar manner; and finally the entire scoring system was reduced to sixteen items.

The next problem was that of assigning values to each major item, knowing that some were of sufficient importance to justify failure to approve a supply, while others were of minor significance. It was agreed that a score of 90 points out of a possible 100 would be required for approval and that a credit of 10 points be given to the more important items, lesser credits being given to other items in proportion to their sanitary significance. The following is an outline of the system now used for rating public water supplies in Tennessee.

Physical Equipment

Item 1—Source of Supply. Under this item are considered adequacy of source, standby sources, impounding reservoirs, surface supplies, springs, wells, pollution hazards, protection works, gravity pipe lines, raw water quality in relation to treatment, and other points of sanitary significance. Full credit for no defects is 10 points and no single penalty or combination of penalties exceeds 10 points. Usual penalties range from 2 to 5 points.

Item 2—Equipment, Buildings and Grounds. Under this item are included all equipment, exclusive of treatment facilities, and buildings and grounds. Equipment such as low and high lift pumps or other mechanical appliances should be adequate to perform the desired service and duplicate units should be installed where necessary to insure continuous service. All buildings and other structures must be well constructed and satisfactory from the standpoint of arrangement, size, material of construction, floor drainage, heating, lighting, painting, ventilation, toilets, lavatories and other necessary

items. The grounds around the water works buildings must be properly graded and drained and present a neat and attractive appearance. Full credit on this item is 5 points.

Item 3—Treatment Facilities. This item includes all treatment units which are considered necessary on any particular supply and may include aerators, chemical feeders, mixing devices, sedimentation basins, filters and appurtenances, disinfection equipment and other facilities of lesser importance. All treatment units necessary to insure a safe water must be in duplicate. Full credit on this item is 10 points, and those supplies requiring no treatment receive full credit, whereas penalties may range from 1 to 10 points for any sub-item, depending upon its sanitary significance.

Item 4—Laboratory Facilities. Requirements vary, depending on what is considered necessary to control the treatment processes involved. On Group A and B plants both chemical and bacteriological facilities are required (this grouping of plants is the same as used in connection with program for certification of operators). If no treatment is provided, full credit will be allowed without any laboratory facilities, whereas, with chlorination only, a chlorine comparator is required. Full credit for having necessary facilities is 5 points.

Item 5—Potable Water Storage Facilities. This item includes all tanks or reservoirs, either ground-level or elevated, used for the storage of water not to be filtered after such storage. Consideration is given each in regard to location, construction, cover, fence, or other points which may have a bearing upon the possibility of contamination entering the water stored therein. Full credit is 5 points and the minimum penalty for an open reservoir is 2 points, with higher penalties, up to 5 points, where danger of pollution is great.

Item 6—Distribution System Piping. Under this item are considered the kind, size and location of pipe lines; number and location of valves, hydrants and blow-offs; and the extent of service. No attempt is made to evaluate the item from the standpoint of fire protection, since interest is primarily in water for domestic and household use. It is required that at least 75 per cent of the population secure water from the public supply. Full credit for the item is only 2 points.

Item 7—Existing Cross-Connections. This item pertains to the existence of any cross-connection, auxiliary intake, bypass or inter-

connection. Since personnel is limited, a complete survey cannot be made in every town, so the water works officials are required to investigate all premises having a private water supply or private storage tank in an effort to find and remove any such connections. In addition it is required that the water works obtain signed agreements from the occupants or owners of the private premises that no unauthorized or unapproved installations exist or be made. These statements are retained in the files of the water works. A statement is then addressed to the health department advising that the check has been made and that no such connections exist. This statement must be signed by the responsible water works or city official. For convenience, a form letter and standard agreements have been prepared and are furnished to each water works. Full credit for compliance with this item is 5 points. If an unapproved connection is made after approval is granted, the approval is revoked and signs removed.

Operation

Item 8—Certified Operator. This applies to the chief operator or other person directly responsible for operation and supervision of the entire water works. In cases where responsibility for plant operation and distribution system operation is delegated to different men, then all should be certified. To become certified an operator must have the required experience and must take the examination given under the supervision of the Division of Sanitary Engineering of the Tennessee Department of Public Health to indicate that he is competent to operate the water works in question. Full credit for compliance with the requirements of this item is 9 points.

Item 9—Maintenance of Equipment, Buildings and Grounds. Under this item is included maintenance of intake works, well or spring collection and protection works, high and low lift pumping equipment, all water works buildings and adjacent grounds or any other equipment and structures exclusive of treatment facilities. General maintenance and housekeeping are considered under this item. Full credit for satisfactory compliance with the requirements is 5 points and the usual penalty is 2 or 3 points.

Item 10—Operation and Laboratory Control of Treatment Works. This item includes maintenance and operation of treatment works, routine chemical and bacteriological laboratory work and the appli-

cation of laboratory data to control of operation. The operation of treatment facilities is considered more important than operation of laboratory facilities. Full credit for the item is 10 points and the penalty on laboratory control does not exceed 5 points, whereas failure to maintain and operate any treatment unit carries a maximum penalty of 10 points.

Item 11—Operation of Distribution System, Reservoirs and Tanks. The general policy of maintenance and operation of the distribution system and appurtenances such as valves and hydrants; routine flushing of mains; disinfection of new mains, tanks or reservoirs or old works which have been subjected to possible contamination; maintenance of tanks and reservoirs or structures such as fences around open reservoirs; and the operation and maintenance of other items of sanitary significance are considered here. Full credit is 4 points and penalties vary from 1 to 4 points, depending upon the sanitary significance of the defect.

Item 12—Cross-Connection Policy. Even though no cross-connections exist, an operating policy should be established to prevent the installation of such connections. A suitable cross-connection ordinance should be passed and authority for enforcement delegated to some responsible water works official. For the purpose of getting standard procedures and for convenience, copies of an ordinance recommended for passage by cities and towns and a standard policy, for adoption by private water companies are available for distribution. Signed copies of the ordinance or policy as adopted must be filed with the State Health Department before credit is allowed for the item. Full credit is 5 points.

Item 13—Cooperation With the State Health Department. Cooperation between water works officials and engineers of the health department is necessary to keep the authorities posted relative to any system. Regular samples and reports provide data on operation and water quality. Plans and specifications must be submitted and approved before construction is started on new work. Also included under the item are other points, such as the reporting, to the health department, of unusual conditions, the request for special service when needed, or other points which indicate the general attitude of officials regarding the production of a safe water at all times. Full credit for satisfactory compliance with the requirements is 5 points and no single penalty or combination of penalties exceeds 5 points.

Water Quality

Item 14—Physical Characteristics. This item includes turbidities in excess of 5, color in excess of 10, and objectionable taste or odor, or any other physical characteristics which would render the water undesirable or unsuitable for general household use. Full credit is 5 points. In general penalties on this item are low, but they may reach the maximum of 5 points in a few cases.

Item 15—Chemical Characteristics. The water must not contain excess iron, lead, manganese, copper, zinc, fluoride or other chemicals which are objectionable. Alkalinity, hardness, chlorides, total solids and calcium carbonate equilibrium are considered, regarding their possible significance on water quality. In general, the U. S. Public Health Service quality standards are used in rating this item. Full credit for satisfactory chemical quality is 5 points.

Item 16—Bacteriological Quality. The bacteriological quality is judged on the basis of the coliform organism content of samples analyzed by the Tennessee Department of Health laboratory during the 12-month period prior to the rating. At least 10 samples submitted during the period are required as a basis for rating the item. Full credit for the absence of coliforms in the 10 or more samples is 10 points and no credit is allowed when the water fails to meet the minimum standards of the U. S. Public Health Service.

General

There are certain cases and conditions under which approval is not granted regardless of the numerical rating or score of the supply. Approval is withheld from any supply having an unapproved cross-connection, auxiliary intake, bypass or interconnection, or where treatment obviously essential to the production of a safe water is lacking. Approval is also withheld if less than 75 per cent of the population is served by the supply, and if the quality of the water furnished to the public fails to meet the standards of the U. S. Public Health Service.

Induction of the Program

Active field work in connection with the program was started early in 1940. Since the program was something new, it was necessary to acquaint city officials and water works officials with the program. This was first done by mail. Each public water supply

was then visited by an engineer from the Division of Sanitary Engineering for the purpose of making a preliminary rating of the supply. At the time of this visit, the program was explained to the operator or superintendent of the water works and to the mayor or some other administrative official. It was considered necessary to make both of these contacts because, in general, provision of the necessary physical equipment is a responsibility of the administrative officials, while operation is the responsibility of the superintendent or operator and because the whole-hearted cooperation of both was necessary if the approval program was to be a success. Usually it was found better to make the rating with the operator or superintendent before contacting the mayor, as the program could then be discussed in terms of the particular water supply in question. All defects were discussed, and methods and means of correction explained. All were advised that a final rating for approval would not be made until after July, 1940, as this time was considered necessary to permit making the necessary changes or improvements.

Following the visit, a letter was written to the mayor, with a copy to the water works superintendent, outlining and discussing all points requiring correction or improvement before approval could be granted. It appeared that most towns were interested and that all wanted the approval signs. It must be remembered, however, that numerical scores were not given on the first visits and recommendation consisted of a blanket request to correct all defects and make the improvements outlined if it was desired that the water supply be in line for approval when inspected during the latter half of 1940.

Before final ratings for approval were projected, an inspection form which included the 16 items discussed, together with sufficient sub-items to insure a systematic and thorough check of the entire works, was prepared. Along the right-hand margin, spaces were left for recording the credit on each item. This form has given the city a clear picture of the reasons for the various penalties, and has materially reduced the amount of correspondence necessary to explain the various defective items. At the time of writing (October, 1940), about 75 per cent of the supplies have been given a final check and only 12 towns have received approval. Several others will be eligible for approval when the operator or superintendent receives a certificate of competency. It is expected that many

operators will attend the water works school to be held next month and take the examination for certification at that time.

Standardization of Scores

The system may appear quite arbitrary, since so much seems to depend upon the judgment of the engineer who is rating a supply. The department is well aware of this and, to eliminate some of subjectiveness of the procedure, has established a preliminary code setting up the amount of penalty for the more common defects found. In other words, the complete code is in the process of preparation, but enough standardization has been obtained, by discussion among the engineers of the staff, to insure a reasonably uniform penalty on each defect. For example, where chlorination is the only method of treatment, a credit of 7 is allowed for the regular chlorinator if it is in good condition and is reliable, and only 3 is given for a satisfactory duplicate or standby chlorinator. The credit for a satisfactory duplicate or emergency machine may be increased to 5 points as the regular machine deteriorates. Also, the credit for a constant rate machine on a supply with variable flow will be only 3 points.

As field work continues more standard penalties will be established and eventually there will be a complete code. It is realized that the system is not yet perfect and that modifications will have to be made; but the department is quite optimistic about the program and about the way it has been received by city and water works officials.

The author wishes to acknowledge helpful suggestions made by Howard D. Schmidt, Director, Division of Sanitary Engineering, and J. Wiley Finney, Senior Engineer, Tennessee Department of Public Health, in the preparation of this paper.

Discussion by *E. Sherman Chase*.* Nearly twenty-five years ago, Theodore Horton and the writer, then Chief Engineer and Assistant Engineer, respectively, in the New York State Department of Health, worked out a rating system for the water supplies of New York. Mr. Farrell's paper and that by Mr. Baylis in the October, 1940, JOURNAL are therefore of particular interest to the writer.

In the matter of rating or scoring the sanitary quality of public

*Partner, Metcalf & Eddy, Consulting Engineers, Boston, Mass.

water supplies, certain important considerations must be borne in mind, namely:

1. Any system for expressing numerically the sanitary quality of water supplies must of necessity be based upon informed judgment and cannot be based upon exact mathematical analysis.

2. The degree of accuracy of any attempt to give quantitative values to immeasurable factors depends upon the judgment and experience of those selecting the values. To a lesser degree, the successful application of rating schedules employing the selected values also depends upon the judgment and experience of those using the schedules.

3. The successful application of scoring systems, no matter how carefully thought out, is contingent upon complete and trustworthy data.

4. Rating systems are foot rules, not micrometers, but if their limitations are appreciated they will serve as important aids to judgment in the matter of the relative hazards involved in the development, protection and distribution of water supplies.

A brief study of the system described by Mr. Farrell indicates the probability that, when more experience is had with it, there are likely to be some modifications. There seems to be some duplication of credits or penalties as regards certain pairs of items, namely, Items 2 and 9, Equipment, Buildings and Grounds; Items 4 and 10, Laboratory Facilities; and Items 7 and 12, Cross-Connections. Furthermore, as far as the supply itself is concerned, it does not seem quite logical to penalize it because less than 75 per cent of the population is served. If a supply is disapproved because less than 75 per cent of the population is served, how can it ever be approved unless the people are urged to connect with a "disapproved" supply.

The proof of pudding is the eating. The system of scoring worked out by Horton and the writer was applied to many public water supplies in New York at a time when water-borne typhoid was sufficiently prevalent to permit a correlation of sanitary scores with typhoid fever death rates. The correlation then obtained was sufficiently good to indicate that the bases for scoring were reasonably accurate and satisfactory. Further experience with and study of the Horton-Chase method for rating water supply quality are given in the report of the committee of the New England Water Works Association as referred to by Mr. Farrell and in a paper by the writer published in the September, 1932, JOURNAL.

One important advantage of any system of grading, as proposed by Mr. Farrell and as suggested by Mr. Baylis, lies in the fact that, to a considerable extent, such a system takes into consideration potentialities of contamination and infection as well as evidence or lack of evidence thereof in the past. Rating of quality based upon analytical evidence only shows what the supply was at the time of sampling, not what it has been at other times nor what it may be in the future.

It should not be forgotten that the Treasury Department standards are just as arbitrary as any rating system and as fully dependent upon judgment and experience. Furthermore, the writer does not recall any published data correlating the prevalence of water-borne disease with analyses for the coliform group of organisms. Such correlation may have been attempted, however.

The limitations of the Treasury Department standards were pointed out in the report of the advisory committee which prepared these standards. These limitations are often forgotten and the simplicity of judging the quality of a water supply by a single analytical determination has led to the neglect of those factors which have to be considered in preparing a sanitary score.

The writer continues to believe that, irrespective of its shortcomings, the scoring of public water supplies by some method of grading which takes into consideration *all* factors affecting water supply quality is practicable and well worth while.

A Simple Method for Location of Cross-Connections In Piping Systems

By R. C. Dohe

THE problem of cross-connections is one that confronts all water works men. It is a problem of many sides, one of the most perplexing being the difficulty encountered in proving definitely that a cross-connection exists and in discovering its location once existence is proved. In general, the problem of cross-connections arises from three types of installation:

1. Where a customer has a private well supply and attempts to operate his plant or building most of the time on water which he produces himself, believing that the cost is less.

2. Where a plant operates a cooling pond or spray tower in connection with a refrigeration plant, an engine of some kind, or air-conditioning equipment.

3. Where operators of both small and large steam boilers connect the city water directly to the boiler for the purpose of filling it with the direct pressure of the city mains.

Other types of cross-connections, such as connections into sanitary plumbing, are, also, often hazardous, but they may be the worry of the plumbing inspector rather than the water works man.

The full danger of a Type 1 cross-connection, wherein the city mains may be flooded with untreated water at some time when the pressure of the mains becomes less than normal, is apparent at once. Type 2, in which a spray pond or cooling tower is cross-connected with a water system, can cause serious contamination because most of these installations use harmful chemicals for the prevention of algae growth and scale and because they are continuously exposed to atmospheric contamination. Type 3 is especially dangerous to the public

A paper presented on October 16, 1940, at the Southwest Section Meeting, Tulsa, Okla., by R. C. Dohe, Superintendent, Light and Water Department, Tahlequah, Okla.

because of the steam from the high pressure boiler that may back up into the water system. Water from the boilers is unsuitable for drinking purposes because of its high concentration of salts and chemicals, used for the prevention of scale formation. Of course, this list could be expanded to include many other types of cross-connections, such as those with fire towers and sprinkling systems, but here those are to be included in one of the three categories mentioned.

The hazards and the liability, assumed by an owner, from the operation of cross-connections are seldom appreciated. Most customers will deny the existence of any cross-connection on their properties. They may not understand what a cross-connection, according to the water works' definition of the term, is, or they may think that the pipes on their property are their own business and that as long as they pay the bill for their water, they are entitled to do what they please with it, including the right to pipe it into their equipment in the manner which best suits their purpose.

The phase of the problem which this paper undertakes to discuss is the matter of proving conclusively and simply that a cross-connection does exist and of locating the cross-connection with a minimum of effort and disturbance to the plant being inspected. The method proposed is very simple and to those accustomed to electrical testing, it will, without any detailed description, appear obviously convenient. For those who are not acquainted with electrical testing methods, however, a more or less detailed description of the equipment and methods of procedure employed are necessary.

Method and Equipment

The method is simply that of measuring the electrical resistance between a convenient point in the piping system and one in the equipment suspected of being cross-connected with it. If the two systems are cross-connected by a metallic pipe, the electrical resistance between the two points will be very low—a few one-hundredths of an ohm. If no cross-connection exists, the resistance will be much greater than this—from several ohms to possibly several hundred ohms.

If the initial test shows a low resistance reading, indicating a cross-connection, a casual survey of the plant should be made for the purpose of selecting the most convenient place for setting up the test to make the final location of the connection. If the plant is

small, the location of the set-up will make little difference. If the plant constitutes a large building or buildings, however, it will be much more convenient to make some preliminary resistance measurements in different parts of the plant, preparatory to setting up the final test. In making the preliminary tests, the resistance in each building or each part of the plant should be noted, the test showing the lowest resistance obviously being the closest to the cross-connection. Several cross-connections may, of course, exist; and under these circumstances, they must be traced one at a time.

A wide variety of equipment may be used on the tests, but that which the author has used most successfully consists of some wire for making the connections, four dry-cell batteries connected in multiple so that a fairly heavy current of approximately $1\frac{1}{4}$ volts can be sent through the piping, and a 30-ampere shunt and millivoltmeter.

Equipment similar to this can be purchased for about $25. That used by the author cost about $45 or $50, but it is an old testing set originally intended for a wide range of direct current testing, and much of it is not used in cross-connection surveys. The equipment can be purchased from any electric company as it need not meet any rigid specifications.

Set-Up of Equipment

In setting up preliminary tests to prove the possibility of a cross-connection, one of the battery wires is connected to a convenient point in the city piping. The other wire is connected to one side of the shunt and the other side of the shunt is connected to the equipment suspected of being cross-connected with the public water supply. The millivoltmeter is then connected to the shunt and the current being drawn by the set-up is noted on the ampere-meter scale of the millivoltmeter. If there is no cross-connection, this reading will be very low, indicating a high resistance. If there is a cross-connection, a fairly high current will pass through the shunt, indicating a circuit of low resistance. From these readings it is very simple to compute the actual resistance of the circuit. Voltage of the batteries need not be read, because when delivering a current of eight or ten amperes, the voltage across the pipes is known to average about $1\frac{1}{4}$ volts. The approximate value is close enough; and, by assuming it, the use of another meter is avoided. In interpreting the readings, the voltage is divided by the amperage to give the resistance of the circuit.

For example, if a current of $12\frac{1}{2}$ amperes is noted, the resistance is 1.25 divided by 12.5, equaling 0.1 ohm.

In his experience, the author has never observed a resistance of more than 0.3 ohm in a system where a cross-connection existed, and usually the resistance has been only 0.1 to 0.2 ohms. It is obviously impossible to have such low resistance values and not have a direct metallic cross-connection between the two systems.

Having made a preliminary test and concluded that a cross-connection exists, the next step is to test the piping for location of the connection. In this operation the millivoltmeter is disconnected from the shunt and, while the current passes through the pipe, the leads of the millivoltmeter are pressed firmly against short sections of the pipe. If current is passing through the pipe, a reading of

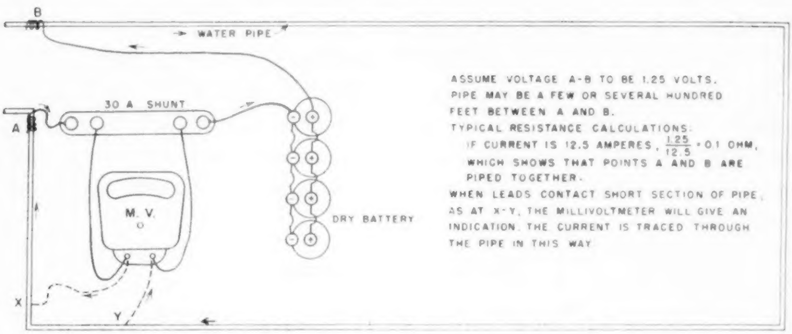

FIG. 1. Apparatus and Method Used

from one to several millivolts registers on the meter. In this way, by working along the pipe, the flow of the current can be traced definitely through the entire circuit, including the cross-connection.

Figure 1 shows the general hook-up of the apparatus and illustrates the method. In this diagram are shown the batteries, the shunt, a loop of pipe through which the current passes, and a typical resistance computation. If the meter is moved along the pipe, a short section of the pipe, such as between X and Y, will then act as the shunt, giving an indication of the flow of the current. It must be remembered that this indication does not measure the actual current because the value of the shunt, X-Y, is not known. The test will give an indication, and this indication will permit tracing the current through the pipe between points A and B.

Application of Method

The method can best be illustrated by some examples of its practical application. Figure 2 is a diagram of such an actual experience. The tests took place in a combination ice and ice-cream plant. Four cross-connections, two of which were deemed hazardous, were discovered. One of the hazardous cross-connections was between points X and Y, where the city water supply was piped into the condenser coils of the ice plant, which were normally cooled by well water circulating over the spray tower. The other dangerous con-

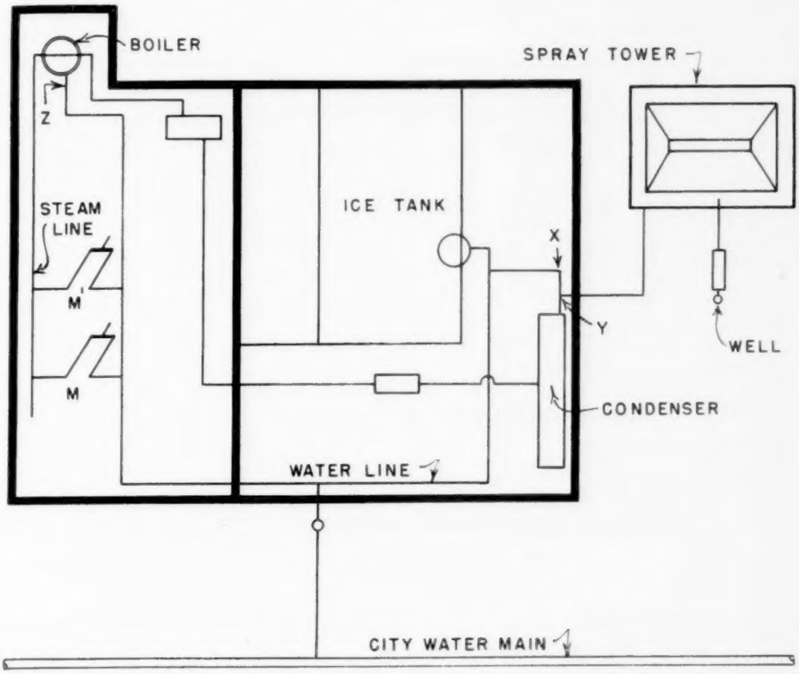

FIG. 2

nection existed at Z, where a direct city-pressure feed was used in the boiler in the ice-cream plant. The two harmless connections were at mixing valves where live steam and city water passed through a mixing device for the purpose of providing hot water. These are shown at M and M'. With a circuit connection between the plant pipe and the water pipe, evidence of a cross-connection was obtained. The resistance was very low, and, as most of the pipe was exposed, the first cross-connection, X–Y, was located by simple inspection. With

this connection removed, the batteries were again connected between the two points and a resistance of approximately 0.06 ohm was noted. The process continued with testing back along the water pipe until it was evident that the other cross-connections were in the ice-cream department. Of course, a great many pipes which are not shown on the diagram, existed; and when the branch which was not carrying current was reached, it was passed without testing. Finally the two points, M and M', were reached and passed to the point, Z. As approximately one-third of the current was flowing in each of three branches, it was concluded that no other cross-connection existed. An inspection of the pipe was, of course, a great aid in tracing out

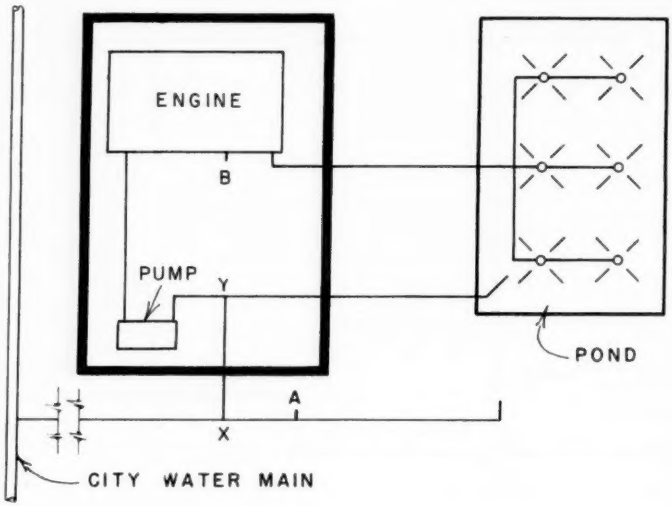

FIG. 3

the current. Altogether about one hour's time for two men was required in this inspection.

Figure 3 illustrates a test made in a plant using an engine and a cooling pond. Batteries were connected to a hydrant in the yard at A and to a valve stem on the engine at B. Cross-connection X–Y was immediately proved to exist and was located.

Figure 4 shows a small part of the pipe in a large manufacturing plant, comprising several acres of land and a number of large buildings. A cross-connection, known to exist at X–Y, had been ordered removed by the water department; and the order had been complied with. The problem was to determine if other cross-connections

existed. The manufacturer used a large amount of cooling water and had a large cooling pond which contained high concentrations of chromates. He had a private water system which was supplied from a well. This water system provided water for certain operations in the plant, including about half of the sanitary facilities. There was also an extensive sprinkler system for fire protection. The city water supply was used to supply drinking fountains, some of the sanitary facilities and to provide such make-up water as was not supplied by the well. The old cross-connection *X–Y*, was inspected and it was selected as a convenient place to connect the

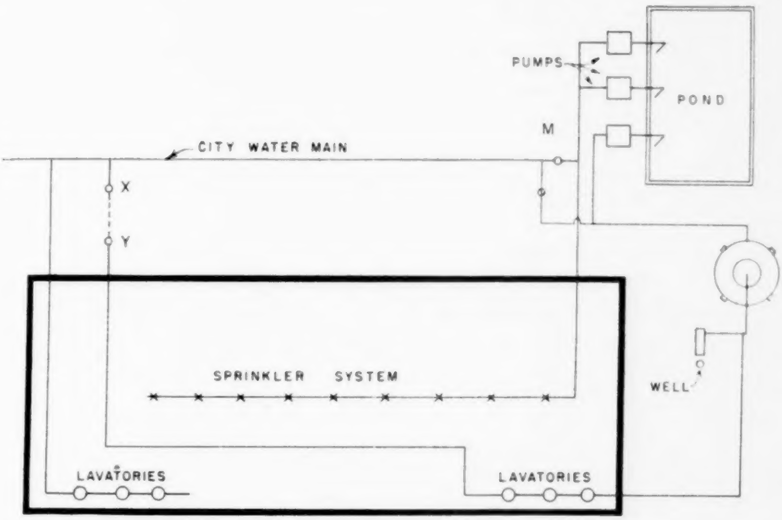

FIG. 4

batteries for a test to see if other cross-connections existed. A resistance of 0.25 ohms was noted, indicating that a connection did exist. The current was then traced through the plant. A cross-connection was located in the sprinkler system, which was supplied with water from the spray pond through two pumps and from the city mains. Other cross-connections were suspected, but because of the large size of this plant it was not feasible to trace out all of the flows of current through the pipe and to find three or four possible connections simultaneously, as was done in the small plant shown in Fig. 2. Further tests are to be made when the cross-connection at *M* is removed.

Figure 5 shows still another application of the cross-connection test. In this case a two-story building with three store rooms on the ground floor was inspected. Many years ago, water was piped into this building as shown by the dotted lines. At a later date, the building was remodeled and separate services were run into Rooms 2 and 3. At still another time, a plumber did some work on the piping and connected Room 2 to the old water service so that it received water without being metered. Since the meter at Room 2 had begun to operate inconsistently, it was taken out, and the batteries set up connecting the gap. The resistance reading showed at once that the piping in Room 2 was in some manner connected to

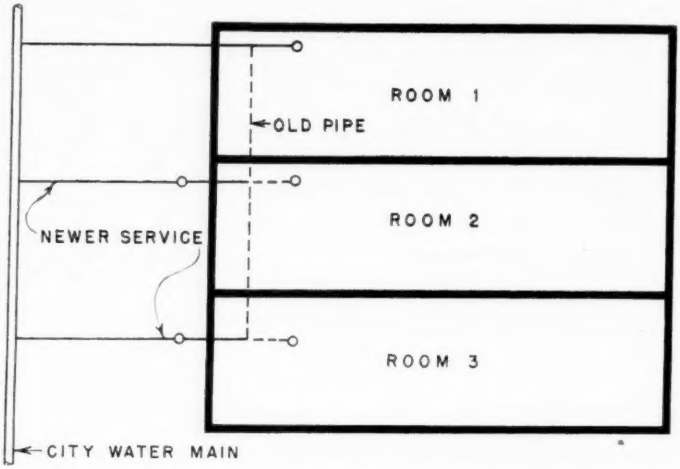

Fig. 5

the water system by a cross-connection with some other service. This was traced out and corrected. No doubt, in this instance, the customer was entirely innocent of attempt to defraud the water department.

In conclusion, the author would like to call attention to the fact that this method uses low currents at a low voltage and depends upon the resistance of the circuit to give an indication of the existence of cross-connections and that, by means of tracing this current, the cross-connections can definitely be located. If the pipes are supported by hangers in metal-frame buildings, some of the current will of course leak off to the structure. It can usually be traced, however, for a hundred feet or more through the piping; and the battery con-

nection can be shifted to energize a new portion. In his limited experience, the author has not found stray building currents to be any problem. If the water pipe is supported on racks it can usually be isolated by slipping a piece of paper under the pipe. Apparatus grounds, if found to interfere, can be removed temporarily. A great deal of the work can, of course, be omitted by substituting visual inspection.

Customers are not told that they have a cross-connection and that it must be removed simply on the basis of a low resistance reading. If this method receives wide approval and if it proves acceptable to water works men, health departments and other inspection services, the time may come when an inspector can go into a plant and, upon finding a low resistance value between the public water supply and the plant's private piping, place the burden of proving that a cross-connection does not exist upon the operators of the plant. For the time being, however, it is preferred that the water department do the necessary tracing and checking and satisfy itself concerning the pipe installations.

Pollution of Drinking Water Through Cross-Connection With Fire Lines

By J. C. Geiger

At 9:19 A.M., Saturday, August 24, 1940, an alarm of fire in the California Building at the Golden Gate International Exposition on Treasure Island in San Francisco Bay presaged the destruction of that large and beautiful building. It introduced a series of events which culminated, as far as this recital is concerned, in the general pollution of the water in the distributing pipe systems in the Exposition grounds.

The water supply of Treasure Island and of the Exposition is furnished by the City of San Francisco through a pipe line laid to Yerba Buena Island across the western portion of the trans-bay bridge. On Yerba Buena Island a covered concrete reservoir with a capacity of 3 million gallons was constructed. Its elevation is such as to give a static water pressure of 250 ft., or 105 lb. per sq.in., on Treasure Island. Under normal conditions both pipe systems are supplied with fresh water directly from the San Francisco system, with the distributing reservoir on Yerba Buena Island floating on the line as a balancing reservoir.

The so-called high-pressure fire-fighting lines and the domestic pipe distributing system are cross-connected at four scattered points (Fig. 1). Three of these cross-connections are manually controlled and each comprises two gate valves with a pressure reducing valve between them. The fourth, at the beginning of the fresh water distribution system at the southwest corner of the island, contains an automatic check valve as well as manually-operated gate valves. The check valve, if operating properly, would prevent the backing up of high pressure (salt) water into the reservoir on Yerba Buena Island and into the domestic supply system at that point. All gate

A contribution by J. C. Geiger, M.D., Director of Public Health, City and County of San Francisco.

valves in these cross-connections are normally open. They are planned to be closed before salt water is pumped into the high-pressure system. Attendants are available at all times and are instructed to close the valves in accordance with this program. The check valve was examined after the fire and found to be in good condition.

At the Port of the Trade Winds, the high-pressure system is provided with a 20-port manifold through which can be pumped salt water from that bay or basin by either of the two fire boats of the City of San Francisco. The fire boat, David Scannell, with a pumping capacity of 10,500 g.p.m., is ordinarily moored at this point. A few minutes, only, are required to lay the twenty 3-inch hose lines from the boat to the manifold.

Health Department Objections to Cross-Connections

When the plans for this water system were first submitted, the San Francisco Department of Public Health objected strenuously to the four cross-connections and to the salt water manifold. It was definitely pointed out that in the event of a fire of any consequence, it would be the height of folly to expect rehearsed routine of closing valves to be carried through in a safe manner. The safety of the drinking water supply was dependent upon too many mechanical operations which, in the event of a conflagration, would have to be carried out withclock-like precision. If any one of the various safety measures was not taken at the proper moment, pollution with salt water would result.

The original plans called for single gate valves at the cross-overs and a single check valve at the low point. The health department requested that at least double manual valves at the cross-connections and double check valves, properly spaced, at the low point be installed. After much discussion, the former were obtained.

Adjacent to the California Building is the South Lake of a series of three interconnecting artificial basins called Lakes of the Nations. These lakes are available as a source of supply for fire engines (pumpers) in virtually unlimited number for a long period of time.

Pollution of the Salt Water Supply

The Port of the Trade Winds, situated between Yerba Buena and Treasure Islands and east of the causeway to the latter, is the home of the trans-Pacific Clippers and serves as an anchorage and berthing basin for many private yachts and other small craft. Its waters

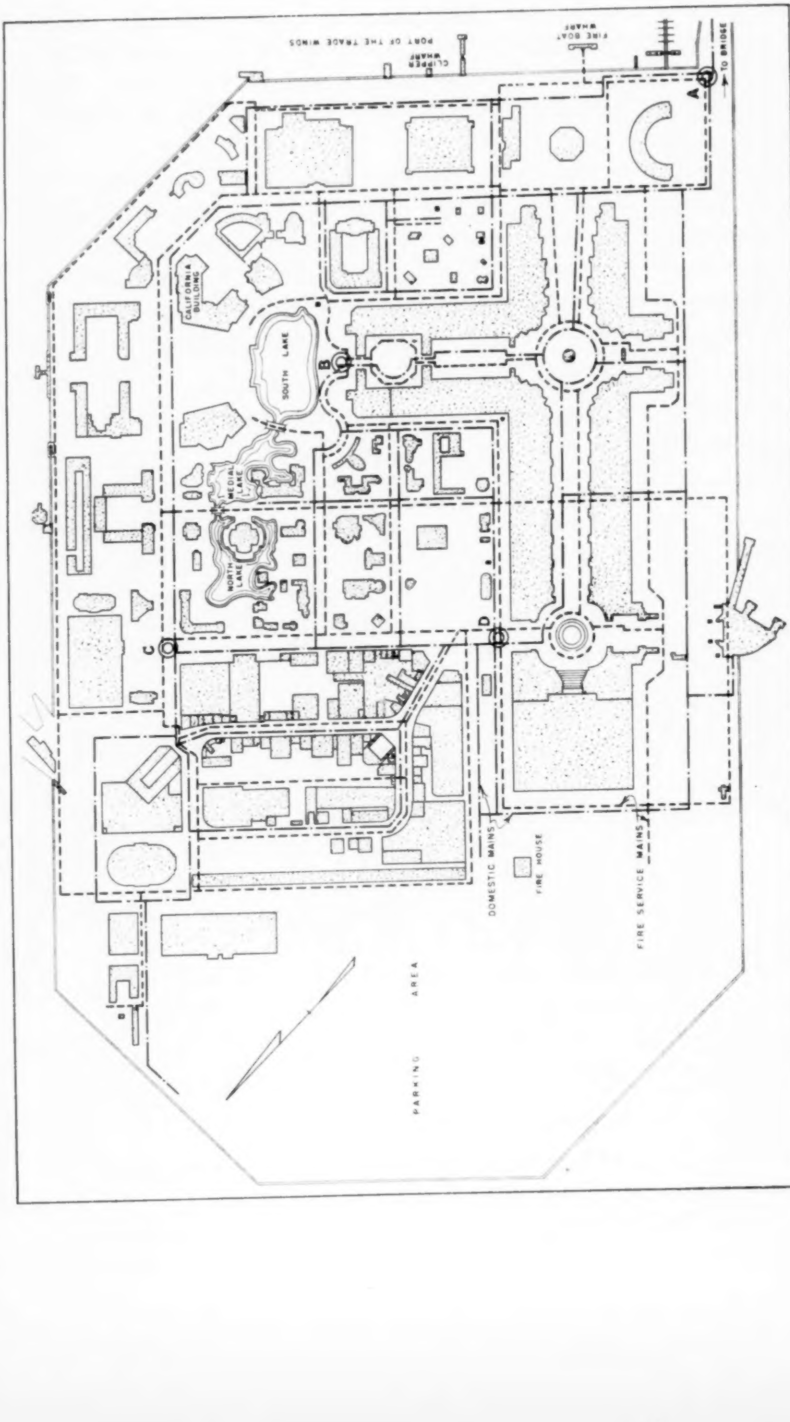

FIG. 1. Layout of Treasure Island; showing Domestic and Fire Service Distribution Systems with Cross-Connections at points A, B, C and D

are subject to pollution from these sources as well as by six sanitary sewers, varying in size from four to twelve inches, serving dwellings, barracks, headquarters and service buildings of the U. S. Naval Station on Yerba Buena Island.

About one year prior to the opening of the Exposition, the health department called attention to the dangerous character of this pollution and made earnest efforts to have the Yerba Buena Island sewers discharged into an intercepting sewer which would convey the sewage to a safe point of disposal. A simple and inexpensive project to that end was developed by the health department. Unfortunately, it proved impossible to secure the cooperation of the proper officials in the matter.

Fighting the Fire

The first alarm of the fire was rung in at 9:19 A.M. The Island fire department responded promptly and laid a number of hose lines from nearby hydrants, of which there were about fifteen available within a distance of approximately 500 ft. from the several facades of the building.

According to its log, the fire boat began pumping into the high-pressure mains at 9:49 A.M., 30 min. after the first alarm. It operated for 16 min., or until 10:05 A.M. At 10:45 A.M., pumping was resumed and continued for 1 hr., or until 11:45 A.M. The log indicates that a pressure of 110 lb. per sq.in. was maintained while pumping. This unit is capable of supplying much higher pressures.

Five alarms were eventually turned in, bringing to the Island a great aggregation of fire-fighting equipment from San Francisco. A fifth alarm would imply the concentration of 24 pumping engines at the site of a fire. Before the fire was finally subdued, 10 pumpers were taking water from the South Lake of the Lakes of the Nations. Moreover, a second fire boat came into action, pumping water from the Port of the Trade Winds through direct hose lines to the building.

Protection of the Drinking Water Supply

The two valves at each of the three points of cross-connection between the high-pressure and domestic pipe systems were said to to have been closed promptly. The records show that this was accomplished by 9:34 A.M., 15 min. after the first alarm and 15 min. prior to salt water pumping operations by the fire boat. An inspector of the Department of Public Health, then on duty on the

Island, examined these valves between 10:00 and 10:15 A.M. and found them all closed. The wheel handles were ordered removed so that they could not readily be tampered with by unauthorized persons. Notwithstanding these precautions, it was discovered about 12 o'clock, noon, that salt water had entered the domestic water supply system.

Samples obtained from well distributed points in the system showed chlorides in concentrations varying from 10 to 16,700 p.p.m. The water supply normally has a chloride content of 9 p.p.m. Chlorides are not readily detectable to the taste until they exceed a concentration of 300 p.p.m. It is possible, therefore, that some people drank water that was contaminated although all drinking fountains were promptly ordered to be shut off. Many of the public lavatories are supplied with paper drinking cups and these were removed. In some instances, janitors posted improvised signs stating that the water was unfit for drinking.

As soon as the saltiness of the supply became manifest, thus indicating its pollution, three inspectors of the health department were sent out to notify each of the 64 restaurants on the Island of this condition and to warn them to cease using the supply. They were instructed to use bottled waters until further notice. The work of warning the restaurants was accomplished in about 45 min. In addition, the Exposition water truck delivered fresh water from the unpolluted supply of Yerba Buena Island.

During this time, and prior to starting the work of disinfecting the water supply system, bacteriological water samples were collected at nine stations scattered throughout the Exposition grounds.

Disinfection of the System

Immediately upon the discovery that salt water had entered the domestic water system, the health department notified the Exposition officials that the drinking water was unfit for use and would be unsuitable until the entire piping system had been thoroughly disinfected. The Exposition authorities called upon the San Francisco Water Department. The Chief Water Purification Engineer was assigned to direct the work of disinfection with the Department's chloro-truck.

The procedure of disinfection may best be described by quoting from the report of the Chief Water Purification Engineer of San Francisco, as follows:

"The portable chlorinating equipment was set up at the southwest corner of the Island, taking a suction line from a fire hydrant and discharging chlorine solution into the domestic system through an irrigation outlet. Chlorinating of the lines was started about 2:00 P.M. and continued until 3:00 A.M., Sunday, August 25, in the domestic system. Between 3:00 and 7:00 A.M. on August 25, the high pressure system was also chlorinated from the same location. As soon as chlorinating was started in the domestic system certain operating valves were closed to force the water to flow in certain channels around the Island. Blowoffs and other valves were opened and allowed to run until chlorine residual was detected at those points, after which they were closed. As each street main became filled with heavily chlorinated solution, men were sent into the buildings to open faucets and flush toilets until chlorine residual was detected at every outlet. This required much time, but was completed about 3:00 A.M. on Sunday, August 25. Chlorine was applied at the maximum rate available at the portable chlorinating equipment and residual in general ran up to 10 or 15 p.p.m. or more.

"While the high pressure system was similarly chlorinated between 3:00 and 7:00 A.M., the domestic system was flushed out so that by opening time on Sunday morning the domestic system was free of excess chlorine in most places and the water satisfactory for use. I requested that the drinking fountains be again turned on and flushed thoroughly until chlorine residual appeared, before chlorination of the domestic system was completed.

"Chlorination of the high pressure system was accomplished by discharging chlorine solution into the system through a fire hydrant at the southwest corner of the grounds and by opening hydrants in other parts of the grounds until chlorine residual appeared in all lines. Special care was taken to flush hydrants on dead ends.

"By the above method it is believed that the chlorine solution reached every foot of piping on the Fair grounds, in both the domestic and high pressure systems."

All restaurants were requested to run water from all spigots for one-half hour to free local lines from heavily chlorinated water before beginning Sunday's operations. All janitors were similarly instructed to run the faucets in the public dressing rooms of all Exposition buildings.

About 9 A.M., Sunday, bacteriological samples were collected at six of the nine stations where samples had been taken on the previous

day. This sampling schedule was repeated on the following Monday afternoon, August 26, and, in addition, surface and depth samples were collected from the Port of the Trade Winds at the point where the fire boat is moored.

Surgeons in the emergency hospital on Treasure Island were instructed to watch for possible cases of gastro-enteritis, and report immediately. No cases were reported.

Bacteriological Findings

The total population on Treasure Island by mid-afternoon Saturday, August 24, was 69,000; that for Sunday, 108,000.

The bacteriological findings on the groups of samples collected on the three days in question may be summarized as follows:

1. On August 24, six of the nine stations sampled showed no *Esch. coli* in 10 ml.; at the other three stations, *Esch. coli* were present in one, two and three tubes, respectively, out of five 10-ml. tubes inoculated with the sample from each station.

2. On August 25, five of the six stations sampled showed no *Esch. coli* in 10 ml., and one station showed one tube positive out of five 10-ml. tubes inoculated.

3. On August 26, no *Esch. coli* were found in any of the five 10-ml. tubes inoculated from samples collected from the same six stations as were sampled on the previous day.

Bacteriological samples collected from the Port of the Trade Winds at the Fire Boat mooring on Monday, August 26, showed the presence of *Esch. coli* in 10 ml. portions but apparently not in 1 ml. portions.

Summary

A fire of large proportions occurred on Treasure Island, the site of the Golden Gate International Exposition, on August 24, 1940, and heavy demand was made upon the water supply for fire-fighting purposes. The water supply piping system at Treasure Island had been set up in two distinct divisions: domestic, and fire-fighting supplies. Four cross-connections between these two supplies were established, three being manually operated gate valves in duplicate, the other being a check valve and gate valves. These dangerous interconnections were installed over the protests of the San Francisco Department of Public Health, which pointed out at the time of original planning that in the case of a conflagration some of the sev-

eral factors upon which the safety of the domestic supply was dependent might not be carried out promptly and pollution with salt water would result. On the day of the fire this very thing happened, resulting in heavy pollution of the domestic supply with salt water.

Within two hours after the salt was noticed in the domestic supply, the San Francisco Department of Public Health through other city agencies had a portable chlorinator in operation thoroughly chlorinating the entire system, and within fifteen hours after the pollution was first noticed, the domestic supply was again in a safe, potable condition. During the time that the polluted water was present, inspectors of the Department of Public Health notified all restaurants to discontinue the use of water from the domestic supply, had drinking fountains throughout the grounds closed down, and gave general warning against the use of the water.

Conclusions

Prompt observation and action by qualified inspectors not only gave protection to the drinking water available to the World's Fair but circumvented the necessity of inconveniencing Exposition officials and the public by a disrupted domestic water supply, which could have been the case for at least 48 hours if such action had not been taken. Careful planning for emergencies in temporary as well as permanent drinking water supply systems is not only economically sound but also excellent public health practice.

On the face of the record, the pollution of the domestic water supply of Treasure Island, at any rate in serious degree, was impossible. Such an extreme degree of pollution did, however, occur. Tell-tale chlorides at certain points in the domestic water supply system were found to approach the concentration in San Francisco Bay water itself. This could not have obtained with closed gate valves in the cross-connections. Under the circumstances there can be but one conclusion—that salt water was pumped from the fire service system into the domestic service system prior to the closing of the cross-connection valves. This conclusion attests most strongly to the validity of the arguments of the health department against any such cross-connections and to the soundness of the statement then made that in a serious emergency "it would be the height of folly to expect rehearsed routine of closing valves to be carried through in a sane manner."

Memorandum by *Charles Gilman Hyde:** The potential pollution of the domestic water supply of the Golden Gate International Exposition on Treasure Island was indubitably much greater than the bacteriological findings actually indicated. Great credit is due to all who shared the work of protecting the Island's population from possibly serious consequences. Among these should be mentioned Dr. J. C. Geiger, Director, and A. B. Crowley, Chief, Industrial Division, San Francisco Department of Public Health; C. J. Brennan, Chief, San Francisco Fire Department; G. E. Arnold, Chief Water Purification Engineer, San Francisco Water Department; and H. C. Vensano, Director of Works, Golden Gate International Exposition.

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* Consulting Sanitary Engineer, San Francisco Department of Public Health.

Manganese in the Loch Raven Reservoir

By Abel Wolman and Robert B. Stegmaier, Jr.

OVER half a century ago, the late, distinguished F. P. Stearns initiated perhaps the first comprehensive studies of the effect of storage upon the quality of water (1). Important, though limited, efforts had, of course, been made prior to that time toward the solution of the problem, but only since then has the continued interest of the profession been held by the issues and conclusions which have developed from various studies on the subject.

In the report of his findings, Mr. Stearns noted a remark made to him by a water works engineer who said: "I don't know what causes these troubles, but I think I know enough about it to demolish any theory which anyone can bring forward."

The same state of affairs appears to persist to this day. There have, of course, been major contributions to the analysis of the effects of storage upon the quality of water, but as new evidence accumulates, some of the accepted conclusions will, no doubt, need adjustment. This is certainly true of the occurrences of such elements of deterioration as are described in this paper. The occurrence of manganese does not appear to follow the general trends, for instance, in the reduction of color in surface reservoirs which have or have not been stripped prior to their introduction into use.

The central issue is still that which was stated in 1891, by Mr. Stearns, in the following terms:

"As storage is an essential feature of most water works, so that we cannot obviate the troubles by doing away with it, the problem

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before us is to provide it under such conditions that there will be the least danger of the occurrence of these troubles."

The conclusions of the studies made by Hazen and Fuller (2) with the collaboration of George C. Whipple, in 1907, still stand relatively undisturbed. It may be assumed today, too, that "the evidence is clear that stripping, alone, cannot be relied upon to produce an impounded water satisfactory as to tastes and odors at all times." Since the complete report on the Ashokan Reservoir has never been printed, the basic conclusion warrants repetition here.

The conclusion which Hazen and Fuller reached was "that this result [i.e. the production of a satisfactory water by aeration and filtration] can be just as certainly and fully accomplished in this way if the Ashokan Reservoir is not stripped as if it is stripped."

Despite the fact that, in the 50 years since the contribution by Stearns, important observations on the same problem have been made by Sir Alexander Houston, George C. Whipple, C. M. Saville (3, 4), Robert Spurr Weston, Charles W. Sherman, Wolman and Powell (5), Karl R. Kennison (6), Gordon Fair and others, the subject still offers a number of challenges to the water supply investigator.

The data presented in this report serve to add another series of detailed observations to the accumulating body of information on the behavior of large impounding reservoirs. The varying occurrence of manganese in a typical reservoir does not follow the general order of sequence, with a declining incidence, characteristic of many of the other ingredients of water supply. Just as tastes and odors in large surface reservoirs are quite independent of the initial physical preparation of the reservoirs, so manganese and perhaps other constituents are apparently independent thereof. Their control, in general, depends upon skillful treatment rather than upon prior preparation of the reservoir area.

History of Loch Raven Reservoir

Gunpowder Falls was first used by the City of Baltimore as a source of water supply in 1871 when a pumping station was installed to supplement the Lake Roland-Jones Falls supply in use at that time. The first dam on the Gunpowder Falls was completed by the city, in 1881, at Ravens Rock (7).

The present Loch Raven dam was built in 1914, with the crest at an elevation of 188 ft. In 1922, it was raised to 240 ft. At this

level the reservoir provides a storage of 23.5 billion gallons, covers an area of 2,391 acres, and the drainage area above the dam is approximately 303 sq.mi.

In 1933, Prettyboy dam was completed. This reservoir provides a storage of approximately 20.4 billion gallons, has a contributing watershed of 80 sq.mi., and is located 15 mi. upstream from Loch Raven dam on the Gunpowder Falls.

Baltimore experienced no difficulties with manganese in its water supply from Loch Raven until the reservoir had filled in 1923, after the elevation had been raised from 188 to 240 ft. At that time an intensive investigation was carried out by John R. Baylis (8), who concluded that the manganese was dissolved from the bottom of the reservoir by organic acids produced in biological processes. This conclusion was based on tests of streams tributary to the reservoir, all of which contained less than 0.10 p.p.m. of manganese, and on the facts that the rocks covered by the reservoir were known to contain small quantities of manganese and that there was a large amount of organic material in the newly flooded portion of the reservoir. Mr. Baylis predicted that, with silting and decomposition of the organic material by biological processes on the bottom of the reservoir, the amount of manganese in solution would decrease in future years.

In 1932, E. S. Hopkins and G. B. McCall (9) demonstrated that, as Baylis had predicted, the magnitude of the annual manganese peaks was smaller each year until the years 1929 and 1930, when, due to drought conditions, there was an absence of silting, which prevented the usual covering of the manganese rock and organic material on the reservoir bottom.

Sources of Data

The chemical and bacteriological analyses of the raw water are the result of tests on samples taken every two hours and combined to make a daily composite sample. The samples are taken from the raw water when it reaches the filter plant after passing through the seven miles of twelve-foot internal diameter tunnel connecting Loch Raven Reservoir with the filter plant.

There are three intake gates at the dam, each 42 in. wide and 72 in. high. Their bottom elevations are 173.5, 204.0, and 220.0. Usually 80 per cent of the water reaching the plant comes through the lowest intake, which is practically at the bottom of the reservoir.

Manganese and Other Reservoir Characteristics

Before work was started on the manganese problem specifically, an attempt was made to find some relation between the manganese and other properties of the water which might have some bearing on the cause of the high manganese content of the water from Loch Raven Reservoir after its elevation was increased in 1921–22.

For this purpose, data were plotted for the years 1919, 1926–27, and 1939, examples of which are shown in Figs. 1, 2 and 3.

In 1919, no manganese had yet been noticed in the water. The daily data plotted were as follows (Fig. 1): iron, turbidity, carbon dioxide, water temperature, air temperature, and rainfall.

The iron and turbidity curves have sharp peaks in every month from February to August. The peaks for the two curves coincide since they are probably caused by the same circumstances. On the logarithmic plot it may easily be seen that each rainfall is followed by an increase in the iron and turbidity content of the water. The highest peaks occur during the period from February to September, in general the months of most intense rainfall. None of the spring peaks can be connected with temperature changes to result in what is known as a spring turnover. In November, when the air and water temperatures decreased rapidly, there was no increase in the iron or turbidity to indicate a fall turnover.

The carbon dioxide curve rises and falls throughout the year, the higher values, as may be expected, occurring during the warmer months from April to September.

The data plotted for the period, July through December, 1926, included iron, manganese, turbidity, dissolved oxygen, carbon dioxide, water temperature, air temperature, and rainfall. The data for this period were plotted because the iron and turbidity contents of the water were unusually high during the first months of 1927.

The manganese curve shows a slow rise from less than 0.10 p.p.m. in early July to 0.80 p.p.m. in mid-October, a peak of 1.43 p.p.m. four days later, and a decline to less than 0.10 p.p.m. in early December. The peak in October follows closely the sharp fall decline in air temperature and consequent lowering of the water temperature. This appears to be the fall turnover.

The iron and turbidity curves, as during 1919, follow one another very closely. They remained low during the period, July to mid-

October, showing no increase when the manganese reached its peak in what was termed the fall turnover. In mid-November very heavy rains and high winds caused a sharp rise in iron and turbidity and the amount did not subside for several months.

A possible explanation of why the manganese did not increase during the November storm is that the fall turnover mixed the manganese of the bottom water throughout the reservoir. The flow produced by the heavy rains, besides carrying a large amount of iron and turbidity due to the air temperature of about 40°F., was as cold as, and probably colder than, the water in the reservoir, so that it moved along the bottom of the reservoir increasing the iron and turbidity. Since the manganese had been disseminated throughout the reservoir earlier, during the fall turnover, it was not increased by the flow from the storm.

The dissolved oxygen content of the water was about 50 per cent of saturation during August, September, and October, the months when the reservoir was stratified. As the temperature of the water began to fall with the attendant turnover, the amount of dissolved oxygen increased to over 75 per cent of saturation.

The manganese curve for 1927 shows the annual peak. It remained less than 0.10 p.p.m. from January till the end of July, when it began to increase slowly to about 0.50 p.p.m. in mid-October, rose to a first peak of 1.06 p.p.m. in three days, dropped to about 0.75 p.p.m. in one day to remain at that level for about eight days. The manganese reached a second peak of 1.10 p.p.m. two days later (November 2) and decreased to 0.10 p.p.m. by December. Again, as in 1926, the peak coincides with the sharp decline of air and water temperatures.

The iron and turbidity curves follow one another closely throughout the year. A very sharp peak occurred in both curves in February. This peak was accompanied by a drop in average air temperature from 57°F. to 35°F. in three days but is further complicated by a heavy rainfall, so that it may or may not be the spring turnover.

During the summer, the carbon dioxide increases and the dissolved oxygen decreases, a change beginning about the same time that the manganese starts to increase in July. It reverses in the fall when the manganese declines from its annual peak.

Most of the heavy rainfalls during the year are followed by increases in the iron and turbidity, but some are not. These latter may possibly be local storms at Baltimore, where the measurements of

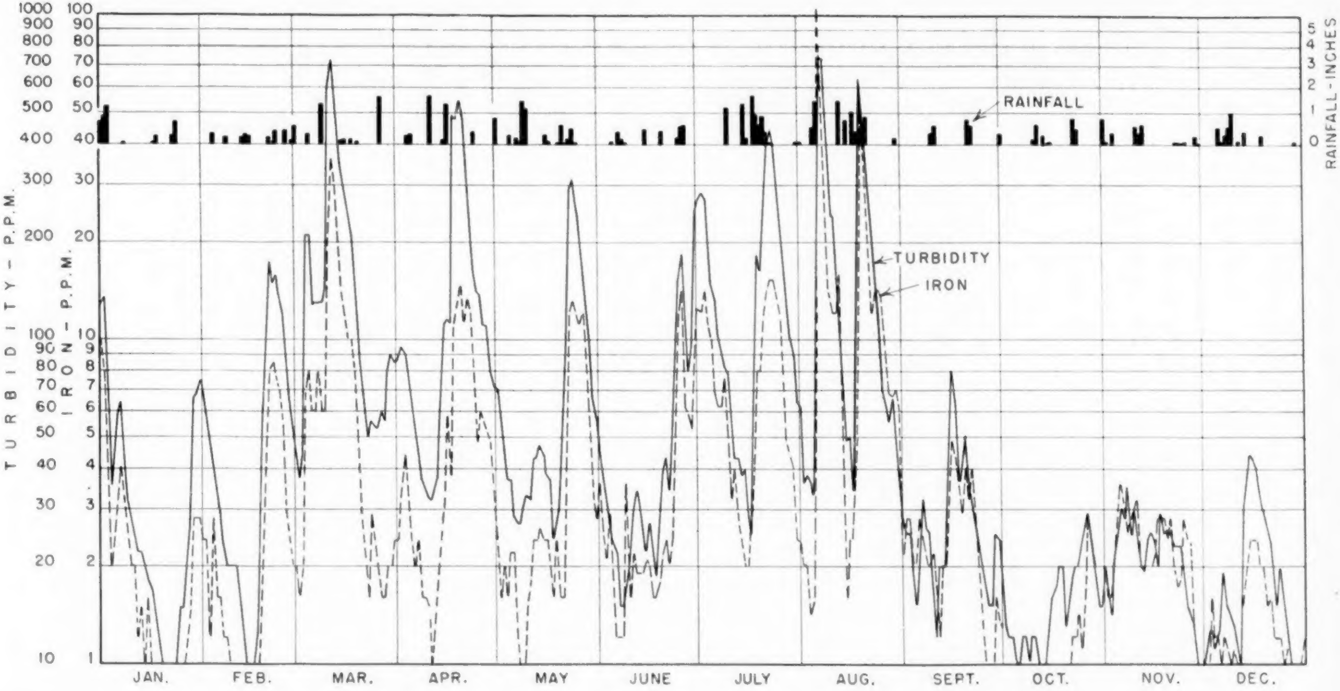

FIG. 1. Iron and Turbidity in Raw Water, 1919; Montebello Filter Plant

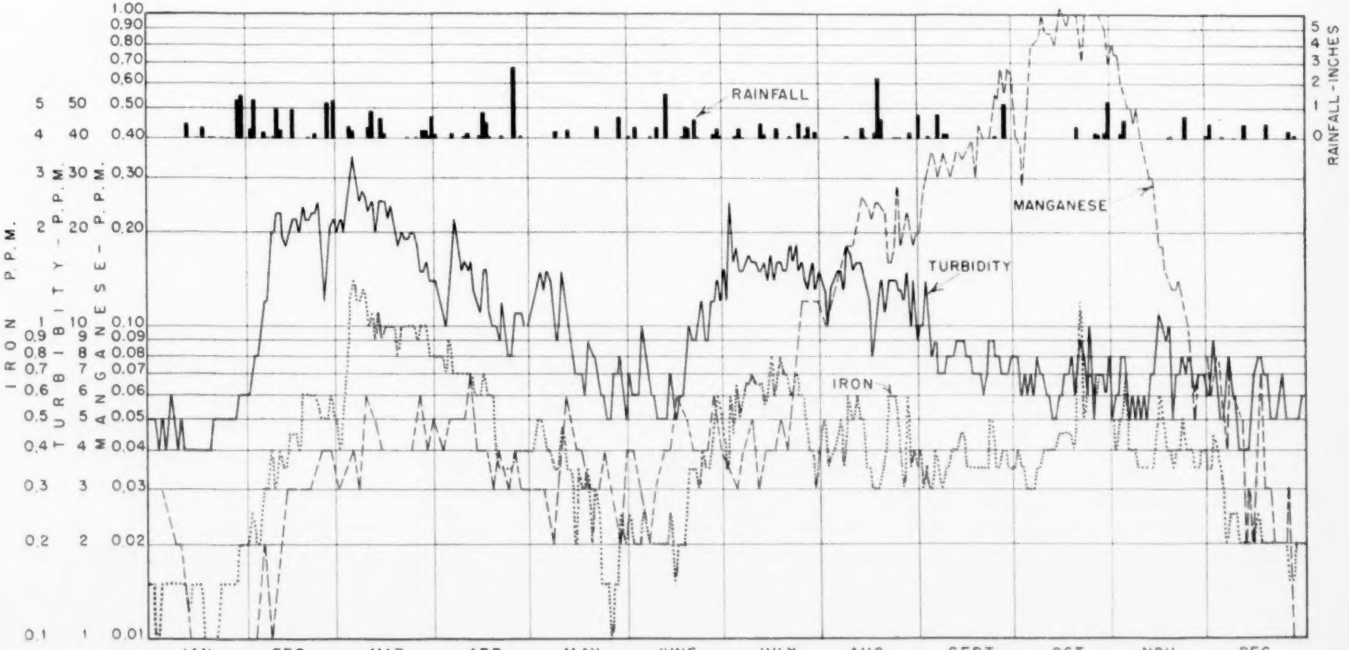

FIG. 2. Iron, Manganese and Turbidity in Raw Water, 1939; Montebello Filter Plant

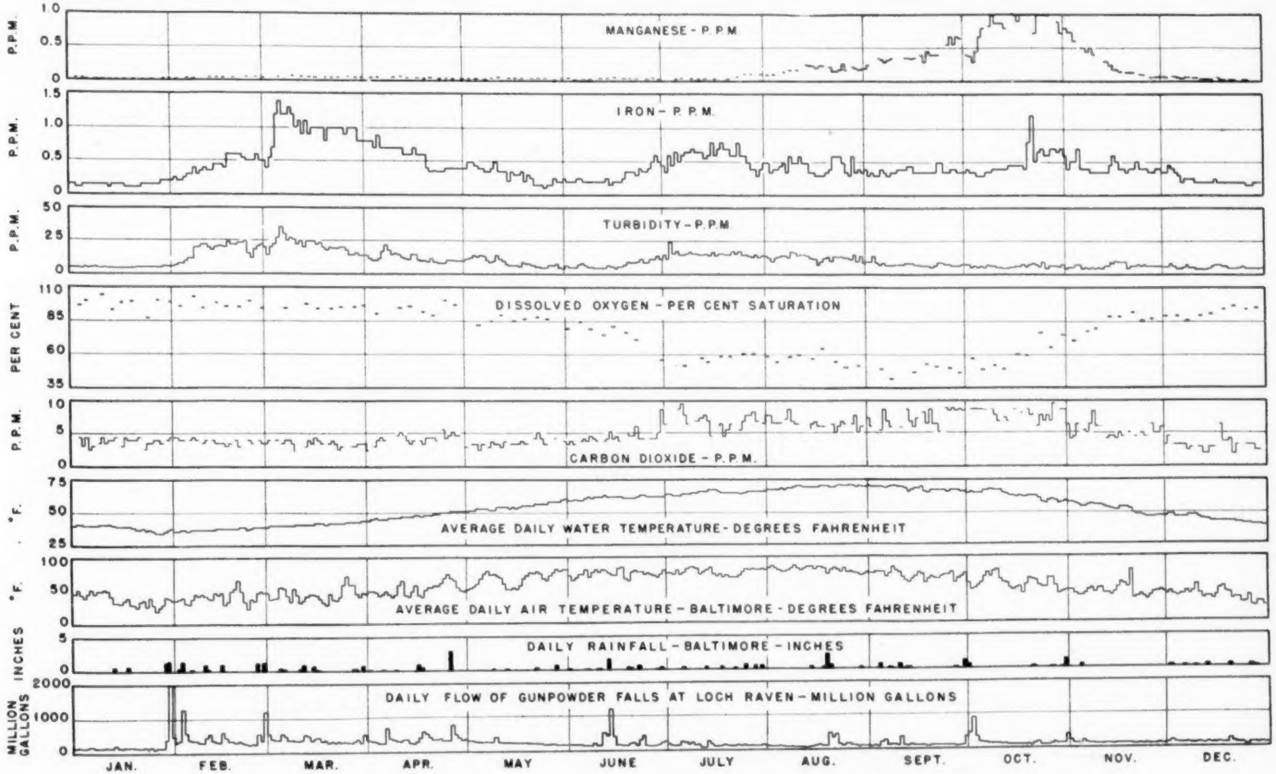

FIG. 3. Properties of Raw Water at Montebello Filter Plant, 1939

rainfall were made. Daily flow records for Gunpowder Falls are not available except after 1930, although monthly figures are on hand for many decades prior thereto.

The data for 1939 include all that were used for 1927, with the addition of daily stream flow records of the Gunpowder Falls at Loch Raven (Figs. 2 and 3).

The manganese was less than 0.10 p.p.m. from January to July. It increased slowly from the last week in July to 0.67 p.p.m. in the last week of September. In one week, a peak of 1.00 p.p.m. was reached and sustained till the end of October. By the last week of November the manganese had declined to less than 0.10 p.p.m. Again, the peak occurred during the rapid decline of water temperature.

The iron and turbidity curves show peaks in March. They are not explained either by temperature changes or stream flow. These peaks occurred when the water was at maximum density, and about two and one half inches of rain fell in two days during the previous week. The air temperature was between 38°F. and 40°F. for three days previous to the peak, and then rose rapidly to about 55°F. These peaks do not appear to be due to temperature changes or flow, but might be attributed to high winds. This is the only case where wind might have played a part in the spring turnover. The sharp peak in the iron curve in October seems to have no explanation.

The carbon dioxide and dissolved oxygen curves are similar to those of 1926 and 1927.

A comparison of the data for 1926, 1927, and 1939 shows that they do not differ materially except for the high iron and turbidity in the winter and spring of 1926–27.

A comparison of these records with those of 1919 shows the effect of increasing the size of the reservoir. The amount of iron and turbidity in the water was reduced and the effect of stream flow on the quality of the water was minimized (10). But offsetting these advantages, the problem of manganese was encountered.

Theory of Manganese Production

Before going any further it might be well to present the hypothesis of manganese production in large reservoirs. The belief of most investigators who have written on the subject is stated in the following paragraph (9):

"The digestion of excessive organic material from the unstripped

reservoir bottom is the underlying cause of the trouble. . . . Water containing free carbon dioxide will dissolve hydrated manganous oxides. Therefore, such water stored over an area of manganeous rock deposits, particularly in deep reservoirs, will under the conditions of fermentation (carbon dioxide production) always contain these soluble salts in the bottom water. At the time of 'seasonal turnover' this element will be distributed throughout the body and become aerated and the soluble salts will be converted into the hydrated oxide."

This explanation is logical in view of the data plotted, for the manganese begins to increase when the dissolved oxygen decreases and the carbon dioxide increases. The explanation also furnishes a key to the variables that might have some relation to the amount of manganese produced each year. Such variables are the amount of organic material available for fermentation, the number of bacteria to digest the organic material, the temperature which possibly affects the number of bacteria, and the stream flow. Storage during the season, and expecially during the turnover, will have a marked effect on the possible dilution of the bottom water.

Manganese Content During the Annual Cycle

The preliminary study and the work of other investigators indicated that the manganese has an annual cycle, and is high only during the late summer and fall months of each year. Figure 4 shows the periods during which the manganese was greater than 0.10 p.p.m. and also the date of occurrence of the annual peak. The arbitrary limit of 0.10 p.p.m. is used because the manganese rarely exceeds this value except during the fall peak of the annual cycle. Reference to Fig. 4 shows that all of the yearly peak daily values of manganese, except four, occurred within a two-week period from October 24 to November 6. The dates when the manganese declined to less than 0.10 p.p.m. each year show little variation except for the years 1923 and 1930. In 1923, the manganese exceeded 0.10 p.p.m. until April 4 of the following year, and in 1930–31, it remained above 0.10 p.p.m. until March 5, 1931. Even though the date of occurrence of the annual peak and the time when the manganese became less than 0.10 p.p.m. varied but little from year to year, the time when the manganese first exceeded 0.10 p.p.m. each year to climb to its annual peak shows a wide variation.

The data for the maximum period of each year's cycle are illus-

trated in Fig. 5. The curves are a plot of the daily amounts of manganese present in the raw water as it reached the filter plant. The period plotted for each year begins June 22 and ends December 19.

Fig. 5 shows exactly how the manganese varied from day to day each year, and provides visual proof that the amount of manganese in the reservoir water does vary according to an annual cycle. The curves also emphasize the previous discussion of the regularity of the time of occurrence of the annual peak.

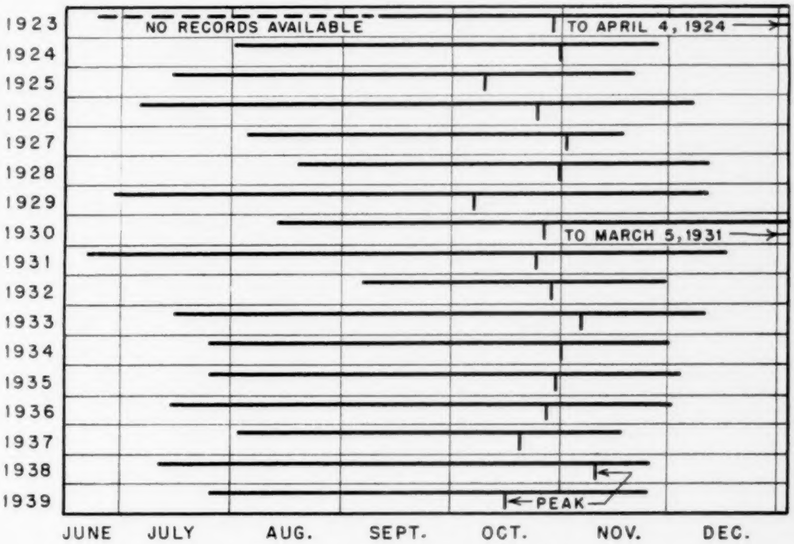

FIG. 4. Periods During Which Manganese Exceeded 0.10 p.p.m. and Dates of Annual Peaks, 1923–39

In order to secure some measure of the manganese during the maximum part of its cycle, duration studies were made for the period July through November of each year. This period was chosen because it covers the maximum part of the annual cycle, and permits the results to be compared directly.

The results of these computations when plotted on logarithmic probability paper provided the duration curves shown in Fig. 6. An inspection of the curves shows that they might all be enclosed within an envelope formed by the two years of high manganese, 1935 and 1931, and the two years of low manganese, 1932 and 1928. The

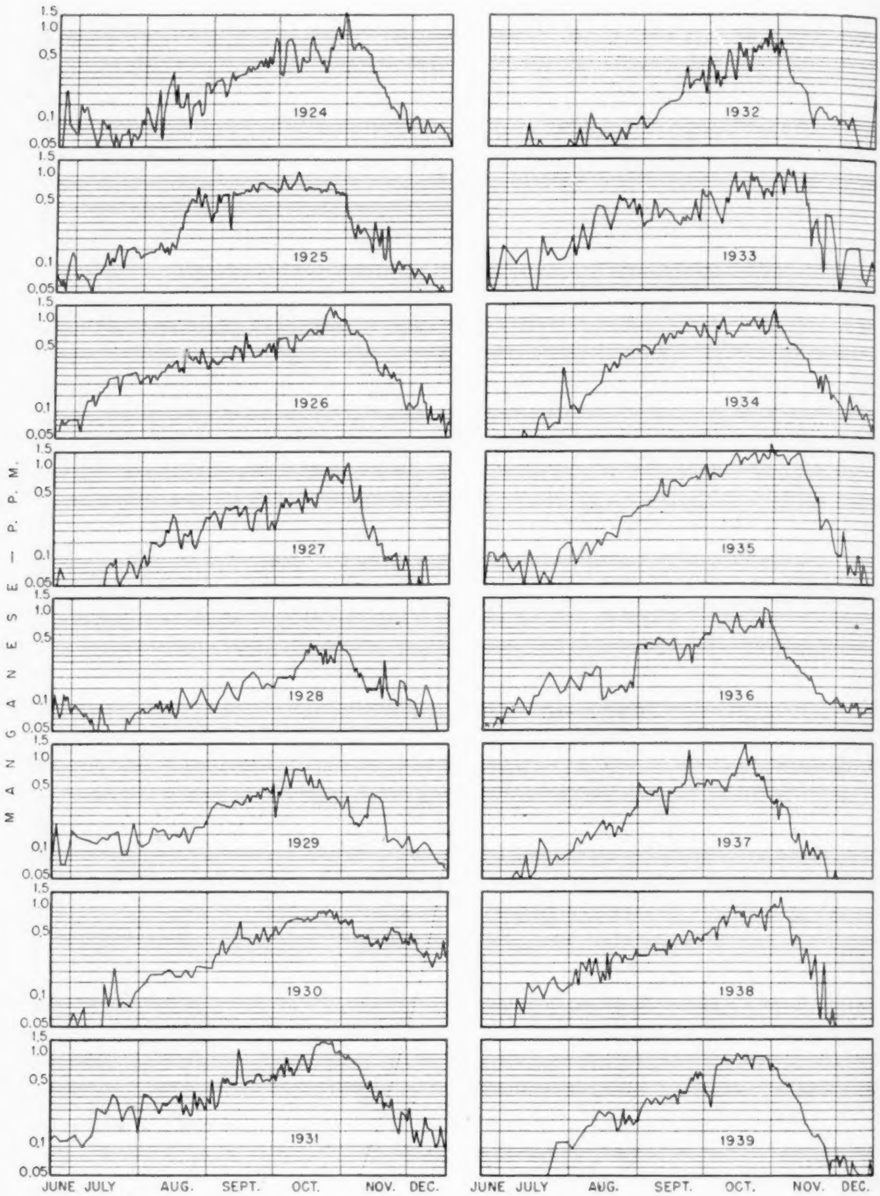

FIG. 5. Seasonal Manganese Peaks, 1924–39

curve for 1928 stands out particularly, because of the extremely small amounts of manganese found in the water during that year.

An obvious and important fact resulting from this study of manganese duration, is that there was more manganese in the water during 1931 and 1935, than in those years immediately following the raising of the dam. From the fragmentary records available for

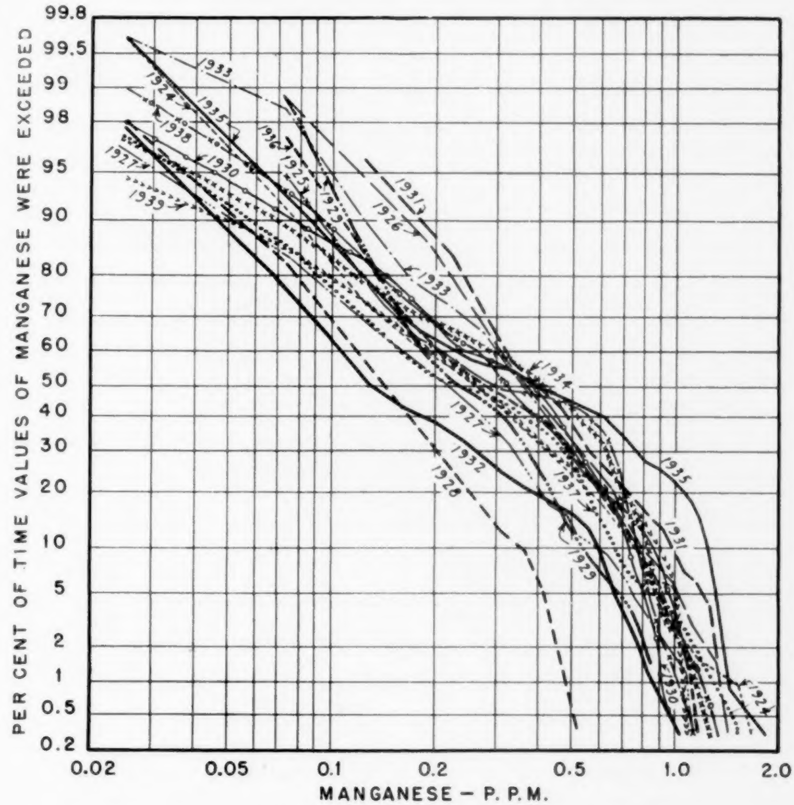

FIG. 6. Manganese Duration for Period, July through November; 1924–39

1923, the first year the reservoir was filled after it had been raised, it seems probable that the total manganese for the year 1923 was greater than any that has occurred. The peak of 1.85 p.p.m. for 1923 is the highest value of the entire record.

The conclusion to be drawn from these data is that, insofar as manganese is concerned, the reservoir, in seventeen years, has apparently not reached what might be called a stabilized condition.

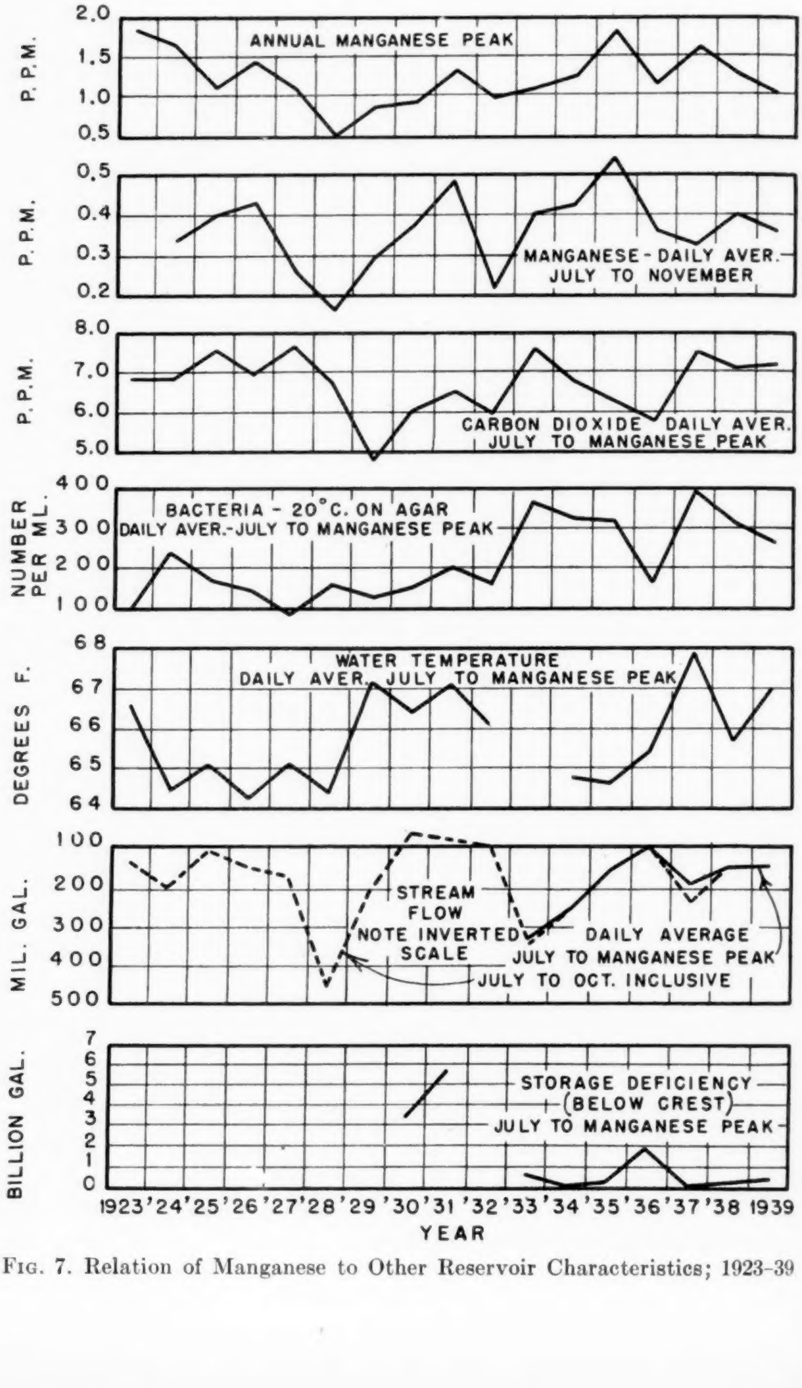

FIG. 7. Relation of Manganese to Other Reservoir Characteristics; 1923–39

Relation of Manganese to Other Characteristics

To find some explanation for the high manganese in 1931 and 1935 a study was made of the factors that might affect the amount of manganese produced each year.

The factors considered were carbon dioxide, bacteria on agar at 20°C., and the water temperature. The average daily values of each of these for the period beginning July 1 and ending on the date of the annual manganese peak were calculated for each year. Storage deficiencies (below the crest) for the years 1930 to 1939, except 1932, were also available. Flow records by days could be obtained only for the years 1933 to 1939. Flow records by months were used

TABLE 1

Manganese Peaks and Averages

YEAR	PEAK DAY	AVERAGE PER DAY (JULY–NOV. INCL.)	YEAR	PEAK DAY	AVERAGE PER DAY (JULY–NOV. INCL.)
	p.p.m.	*p.p.m.*		*p.p.m.*	*p.p.m.*
1923	1.85	—	1932	1.00	0.222
1924	1.67	0.339	1933	1.10	0.401
1925	1.11	0.401	1934	1.25	0.426
1926	1.43	0.437	1935	1.80	0.540
1927	1.10	0.267	1936	1.16	0.362
1928	0.50	0.166	1937	1.57	0.328
1929	0.86	0.290	1938	1.30	0.390
1930	0.92	0.376	1939	1.05	0.356
1931	1.33	0.485			

to calculate the average flow for the period July through October for the years 1923 to 1939.

When possible, the period July 1 to the date of the manganese peak was used, since after the fall turnover none of the factors considered appear to have any influence on the total amount of manganese produced in any one year.

Tables 1 and 2 and Fig. 7 show the results obtained. No one of the factors considered parallels the manganese so closely that it may be designated as the sole cause or regulator of increased or decreased manganese.

Inspection of Table 1 shows that the magnitude of the actual daily peaks is a good index to the average amount of manganese in the water for the high portion of the annual cycle. The carbon

dioxide and bacteria curves do not parallel one another as would be expected, except after 1930. The curve of average daily temperatures does not parallel closely any of the other curves, but does show that the water temperatures were high during the drought period, and that the year of highest average temperature was 1937.

TABLE 2

Data on Manganese and Other Characteristics

YEAR	MANGANESE	CO_2	BACTERIA	WATER TEMPERATURE	STORAGE DEFICIENCY	STREAM FLOW July to Mn Peak	STREAM FLOW July to Oct.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	p.p.m.	*p.p.m.*		°*F.*	*billion gal.*	*mil. gal.*	*mil. gal.*
1923	—	6.85	88	67	—	—	114
1924	0.339	6.81	243	64	—	—	195
1925	0.401	7.51	171	65	—	—	109
1926	0.437	6.97	143	64	—	—	143
1927	0.267	7.64	84	65	—	—	166
1928	0.166	6.74	162	64	—	—	453
1929	0.290	4.79	133	67	—	—	224
1930	0.376	6.09	151	66	3.40	—	63
1931	0.485	6.50	206	67	5.35	—	74
1932	0.222	5.97	158	66	—	—	95
1933	0.401	7.59	368	—	0.60	328	335
1934	0.426	6.74	321	65	0.00	254	254
1935	0.540	6.25	315	65	0.30	153	153
1936	0.362	5.82	164	66	1.95	97	96
1937	0.328	7.44	395	68	0.10	189	222
1938	0.390	7.10	314	66	0.15	141	143
1939	0.356	7.15	269	67	0.45	138	136

(1) Manganese—average per day, July to November inclusive.

(2) Carbon Dioxide—average per day, July to manganese peak.

(3) Bacteria, 20°C. Agar—average number per ml. per day, July to manganese peak.

(4) Water Temperature—average per day, July to manganese peak.

(5) Storage Deficiency (Below Crest)—average per day, July to manganese peak.

(6) Stream Flow—average per day, July to manganese peak.

(7) Stream Flow—average per day, July to October inclusive.

The average daily amounts of stream flow parallel the amount of manganese for each year more closely than any other of the factors considered. This is so with the exception of 1935, the year of maximum manganese production since 1923. By checking back in

the original stream flow records it was found that the flow for July, 1935, was about average, but the flow for the month of August was unusually low, and almost half of the flow for September occurred on two days during the first week of the month. The original data on the reservoir elevations showed that the reservoir was near crest elevation for the entire summer. Therefore, the reservoir characteristics of flow and elevation for the year 1935 are similar to those that existed during the drought years. This situation permits an explanation of the high manganese for 1935, as well as 1930 and 1931. It supports the hypothesis that the manganese is indirectly due to biological activity on the reservoir bottom, which is less disturbed

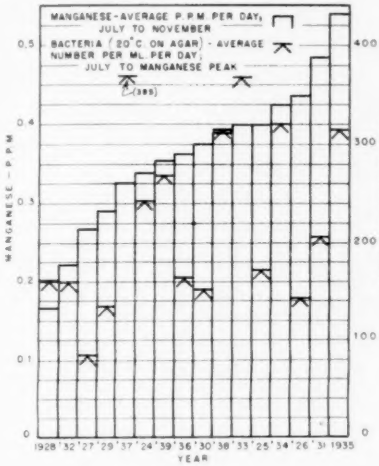

FIG. 8

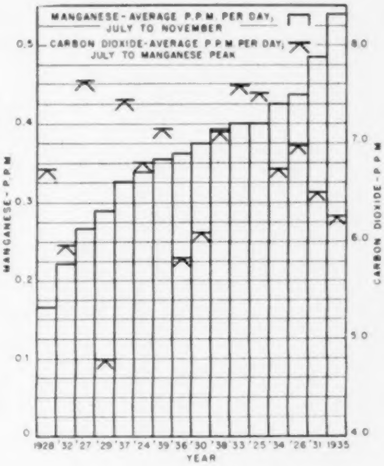

FIG. 9

FIG. 8. Relation of Manganese to Bacteria; 1924–39
FIG. 9. Relation of Manganese to Carbon Dioxide; 1924–39

during years of low flow and low reservoir elevations. During these same years there is also less water available to dilute the bottom manganese-bearing strata of the reservoir, when the fall turnover occurs.

An effort was made to correlate the manganese with the number of bacteria and the amount of carbon dioxide present each year. In both cases the average daily amounts of manganese were first plotted in the order of their magnitude, and then the average values of the carbon dioxide and the number of bacteria for the respective years. The results for the manganese and bacteria are shown in Fig. 8, and for the manganese and carbon dioxide in Fig. 9. Within a wide

range it might be concluded that the number of bacteria per milliliter on agar at 20°C. does have some relation to the amount of manganese in the water each year, and the same might be said of the carbon dioxide, although the evidence is by no means definitive, under the conditions of sampling

Periods of High Manganese Content

Table 3 and Fig. 10 show the result of an analysis of the periods during which the manganese exceeded 0.10 p.p.m. The total time

TABLE 3

Manganese, Total Time Each Year Greater Than 0.10 p.p.m. and Time to Rise to and to Descend from Annual Peak

YEAR	AVERAGE PER DAY (JULY TO NOV. INCL.)	TIME IN DAYS		
		>0.10 p.p.m.	>0.10 p.p.m. to Peak	Peak to <0.10 p.p.m.
	p.p.m.			
1923	—	—	—	158
1924	0.339	90	61	29
1925	0.401	130	87	43
1926	0.437	156	111	45
1927	0.267	105	89	16
1928	0.165	116	73	43
1929	0.290	166	100	66
1930	0.376	235	104	131
1931	0.485	207	152	55
1932	0.222	84	52	32
1933	0.401	159	113	36
1934	0.426	129	98	31
1935	0.540	132	96	36
1936	0.362	140	105	35
1937	0.328	107	78	29
1938	0.390	136	116	20
1939	0.356	132	82	40

during which the manganese exceeded 0.10 p.p.m. in the fall portion of the annual cycle was divided into the time required to rise from 0.10 p.p.m. to the annual peak and the time required to decline to less than 0.10 p.p.m.

As might be expected, the amount of manganese is related to the total time it exceeded 0.10 p.p.m. with the exception of 1935, which, by reference to Fig. 5, is noted to have a longer sustained peak than

other years. Furthermore, the time necessary for the manganese to reach its annual peak is related to both the amount of manganese and the total time it exceeded 0.10 p.p.m., with the exception of 1935. Besides having a longer sustained peak in 1935, the manganese also climbed to higher values in a shorter time than it did in other years.

The time required for the manganese to decline from its peak to less than 0.10 p.p.m. varies very little from year to year, as was

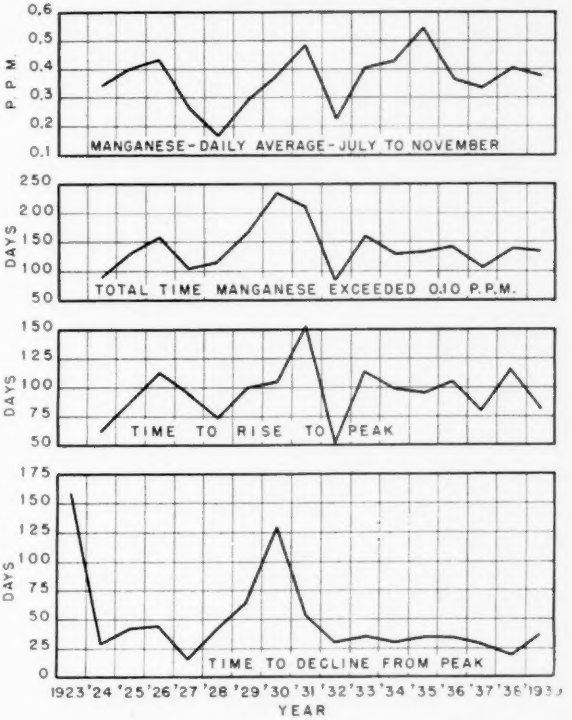

FIG. 10. Relation of Amount of Manganese to Period When It Exceeded 0.10 p.p.m.; 1923–39

previously noted in reference to Fig. 4. The unusually long duration of the manganese above a value of 0.10 p.p.m. in 1930 might be explained by the low flows of the late fall and winter of 1930–31, which did not provide the usual dilution and changes of the reservoir water possible during years of greater flow.

Figure 11 illustrates the same data. The periods, measured in days during which the manganese exceeded 0.10 p.p.m. each year,

are plotted in the order of their magnitude, and on these are superimposed the periods required, during the respective years, for the manganese to rise to and decline from its annual peak. Figure 11 shows clearly the manner in which the total length of time the manganese exceeded 0.10 p.p.m. parallels the time required to reach the actual peak and also the small variation in the time required for the manganese to decline from its peak to less than 0.10 p.p.m. each year.

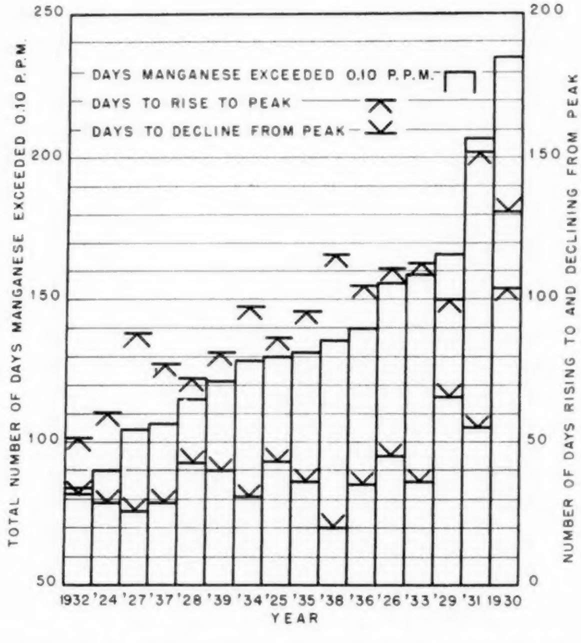

FIG. 11. Relation of Total Time Manganese Exceeded 0.10 p.p.m. to Time to Rise to and Decline from Peak

The manganese peaks occur at about the same time every year, and the time required by the manganese to increase from 0.10 p.p.m. to its peak is a rough measure of the total amount of manganese produced during the peak of the annual cycle and the actual peak. Therefore, the time, when the manganese first exceeds 0.10 p.p.m. and increases past that value to climb to its annual peak, is an indication of the total amount and the actual peak value of the manganese to be expected for that particular year. That is, if the manganese exceeds 0.10 p.p.m. on July 15 and keeps increasing, a greater total

amount and peak value of manganese might be expected than if it had first exceeded 0.10 p.p.m. on August 15.

Conclusions

The preliminary study of the manganese and other reservoir characteristics for the years 1919, 1926–27, and 1939, confirms the work of other investigators. Increasing the size of the reservoir reduced the amounts of iron and turbidity in the water, and reduced the rapidity of changes in the character of the water. The manganese has an annual cycle which is closely paralleled by the increase in carbon dioxide and by the reduction in the amount of dissolved oxygen in the water.

Most rains seem to exert some influence on the manganese, iron, and turbidity curves. The manganese peaks coincide with the decline of water temperatures in the fall, signifying a turnover. This has actually been confirmed for several years by taking samples at various depths in the reservoir.

The iron and turbidity curves always follow one another closely, but the manganese, except for a slight increase in the spring, seems to be affected by altogether different circumstances.

The duration study emphasizes the regularity of occurrence of the annual manganese cycle, and the similarity of its cycles. The years of highest manganese, since 1923, were 1931 and 1935. The duration curves lead to the conclusion that, insofar as manganese is concerned, Loch Raven Reservoir has not as yet reached a stabilized condition after at least seventeen years.

The study of the relation of the manganese to other reservoir characteristics furnished no conclusive evidence to support or to discredit the hypothesis that the amount of manganese in the reservoir is dependent on biological activity.

The quantity of stream flow during the summer months inversely parallels the amounts of manganese found in the reservoir. The years when the stream flow was high, the manganese was low, and vice versa. Of course, the amount of stream flow also influences the amount of storage, and therefore the amount of dilution of the manganese during the fall turnover. If the production of manganese is dependent on biological processes on the bottom of the reservoir, the data indicate that these processes are interrupted, or their effects are masked by stream flow.

The analyses of the annual cycles showed that the total length of time during which the manganese exceeded 0.10 p.p.m. and the time required for the manganese to reach its annual peak are related to the total amounts of manganese produced each year.

In general, the time required by the manganese to decline from its peak to less than 0.10 p.p.m. is fairly constant.

The earlier the manganese begins to increase in its annual cycle the higher the peak will be. The peak usually occurs about November 1.

Acknowledgements

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Distribution System Analysis in Edmonton

By C. K. Hurst

THE City of Edmonton, with a population of 90,000, is located on the North Saskatchewan River about 150 miles east of the Canadian Rocky Mountains. Edmonton, literally the "Gateway to the North" is the northernmost city in Canada. For the past ten years the population has increased at the rate of 1,400 per year, and, with the opening up of the North Country, this rate of increase should remain fairly constant in the future.

A growing population should indicate a growing demand upon the water works distribution system. This, however, is not the case in Edmonton. The city is still in the period of adjustment that always follows times of expansion caused by "boom psychology."

In the pre-World War boom period, the Edmonton water works system, like those of many other western cities, was extended beyond the ordinary limits of conservative design. As a result of this expansion, the system has been contracted instead of expanded during the last twenty years.

An examination of the statistics for the period 1930–38, reveals some apparently contradictory figures. The population increased from 77,000 to 88,000. The water pumped from the treatment plant into the system dropped from 2.7 to 2.4 billion gallons year. The real per capita consumption increased from 50.0 to 54.0 gallons per capita per day. The explanation of this apparent discrepancy lies in the increase in the efficiency of the system during the period.

This general tendency for decreased pumpage due to improvement in efficiency is gradually being balanced by increase in demand due to growth in population. According to recent computations (1), the period of decline in apparent consumption will end in 1943.

A contribution by C. K. Hurst, Hydraulic Engineer, Water Works Distribution System, Edmonton, Alta., Canada. The paper was a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Department of Mechanics and Hydraulics, University of Iowa.

The present period of adjustment offers an excellent opportunity for analyzing the system and planning for future development. The scope of this thesis will be limited to an analysis of the south part of the Edmonton system.

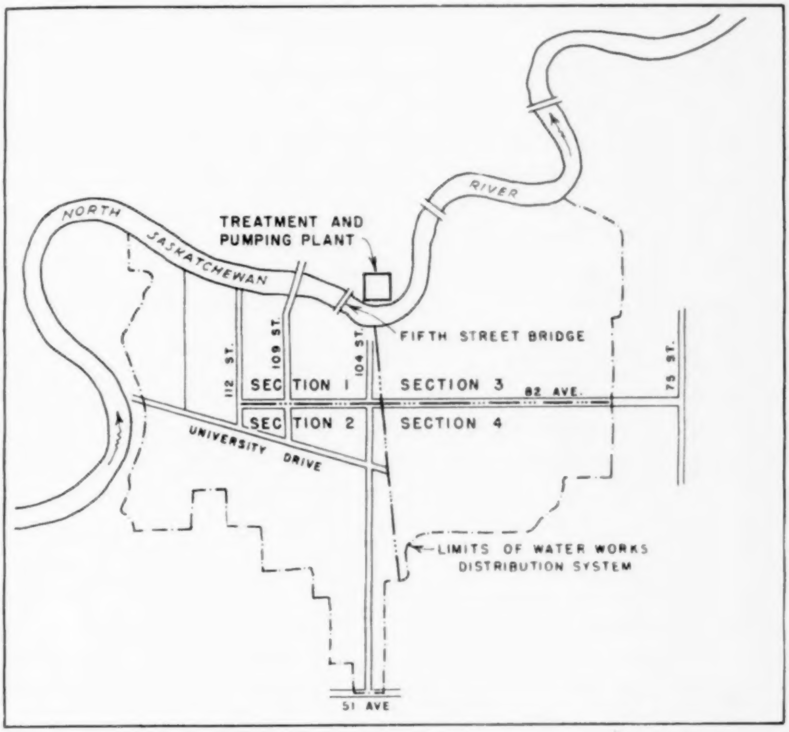

FIG. 1. South Side of Edmonton; showing 4 sections of analysis

Distribution System

In 1902, the first pipe was laid in the city. Since that time the system has grown into a complicated network of 255 miles of pipe. Engineering judgment, occasionally influenced by political expediency, has been the criterion for design.

The Saskatchewan River flows through the city of Edmonton dividing it into two main parts—the south side composed of residential districts and one small business center; and the north side where the main business district and some residential sections are

located. Figure 1 is an outline of the south side of city. The water works treatment and pumping plant is shown on the north bank of the river. The water mains run from the plant to the south side of the city—an 18-inch and a 12-inch main crossing the Fifth Street Bridge and a 20-inch stand-by crossing on the river bottom.

Methods of Analysis

The use of pipe in the conveyance of water has always entailed the use of some sort of engineering design. In early times the method was "cut-and-try," and until quite recently this method was still the most popular. Engineering judgment and experience served as text books.

At the present time there are several methods in use: the equivalent pipe method; trial and error; mathematical analysis; electric network analyzer; the Aldrich method; and the Hardy Cross system which is rapidly becoming the most popular.

Equivalent Pipe Method (2). For simple systems, and cases where there are two or more pipes connected in parallel, the equivalent pipe method can be used with ease. This method consists of substituting for the system a single pipe which, for a given pressure drop, will deliver the same flow as the system. Complicated networks, in some cases, can be simplified by applications of this method.

Trial and Error (3). In the trial and error method a division of flow is assumed at each pipe intersection. The corresponding head losses are computed for the trial flows thus set up for each pipe. If the head loss between any two junction points is not the same for all routes, the trial division of flow is in error and another trial must be made.

Mathematical Analysis (3). In the flow between two points through two parallel pipes, for a given discharge, there are five unknowns: the discharge through each pipe, the head loss through each pipe and through the system as a whole. Five equations may also be written which make a solution possible.

For each single pipe added to the system there are two more unknowns, and two more equations available. Any system is susceptible to analytical solution, but the number of equations that must be solved simultaneously increases rapidly with the number of pipes added.

Electric Network Analyzer (3). The "hydraulic and electric analogy" suggests the use of an electric calculating board or network

analyzer for the solution of hydraulic problems. Each pipe or element in the hydraulic system can be represented by a resistance in a similar electric network. The reservoir or source of water supply can be represented by a battery or other source of current. The method is to make an electric model of the hydraulic system; measure the quantities directly and transfer them into hydraulic figures by a conversion factor.

The inherent disadvantage in this method is the necessity of using expensive equipment.

The Aldrich Method (4). This approach to the problem of the analysis of any distribution system is complicated and for detailed information the original article should be read. In general, the first step is the simplification of the system by the method of equivalent pipes and the second, complete analyses by graphical methods.

Hardy Cross System (5). The Hardy Cross method of analyzing flow in a distribution system is the best method yet devised for the general problem. The following brief abstract gives the general outline of the method.

Two laws govern the solution of flow in a network of pipes:

1. The total flow reaching any junction equals the total flow leaving it.

2. The total change in potential along any closed path is zero.

The problem can be attacked from two different angles. If the flows be taken as unknowns, the equations will be those of continuity of potential; if the potentials are the unknowns, the equations will be those of continuity of flow.

In a networks distribution system it is much easier to compute flows going into any particular district than it is to measure pressure heads at a number of points simultaneously. For this reason the "Method of Balancing Heads" is most applicable to the Edmonton problem.

The law determining the loss of head in a length of pipe for a given flow is of the form:

$$h = rQ^n \qquad (1)$$

in which h is the loss in head; r is the loss in the pipe for unit quantity of flow and depends on the length, diameter, and roughness of the pipe; and n is an exponent of the order of 1.75 to 2.00. If there is a flow of quantity Q in a pipe having a resistance r, the resistance to

this flow is equal to rQ^n. This resistance to flow is equal to the head loss in the pipe due to the flow.

If this flow is increased by a quantity ΔQ the new resistance to flow will be:

$$r(Q + \Delta Q)^n$$

By expanding this expression, the result is

$$h + \Delta h = r(Q^n + nQ^{n-1})\Delta Q + (n - 1)Q^{(n-2)}\Delta Q^2 \ldots)$$

and neglecting all quantities of the second order

$$h + \Delta h = rQ^n + rnQ^{n-1}\Delta Q \quad \ldots\ldots (2)$$

but $h = rQ^n$, so the increase in resistance Δh will be:

$$\Delta h = nrQ^{n-1}\Delta Q \quad \ldots\ldots (3)$$

This is the resistance to flow ΔQ. For unit flow the resistance will be:

$$\frac{\Delta h}{\Delta Q} = nrQ^{n-1}$$

$$\Delta Q = \frac{\Delta h}{nrQ^{n-1}} \quad \ldots\ldots (4)$$

The method of solution is as follows:

1. By using the information available, estimate a distribution of flow.
2. Find the loss of head $h = rQ^n$ along the various pipes of the network.
3. With due attention to sign, compute the total head loss around each elementary closed circuit.
4. For each closed circuit compute the sum of the quantities $R = \Sigma\ nrQ^{(n-1)}$ without reference to sign. This gives the resistance of unit flow around the closed circuit.
5. Set up in each circuit a counterbalancing flow to balance the head in each circuit.

$$\Delta Q = \frac{\Sigma rQ^n \text{ (with due attention to direction of flow)}}{\Sigma nrQ^{(n-1)} \text{ (without reference to direction of flow)}} \quad \ldots (5)$$

6. With the correction ΔQ, make a redistribution of flow and repeat the procedure until the connections are as small as desired.

Application of Hardy Cross Method

Numerous papers have been published modifying the original Hardy Cross method (6, 7, 8, 9). Most of them have dealt with simplifications and tables for the solution of the pipe friction formulas.

The distribution system was divided into four parts (Fig. 1). Using a scale of 300 feet to the inch each part was drawn upon a separate piece of tracing paper with all pipe resistances marked. From these tracings black line prints were made. The actual computations were made on the black line prints.

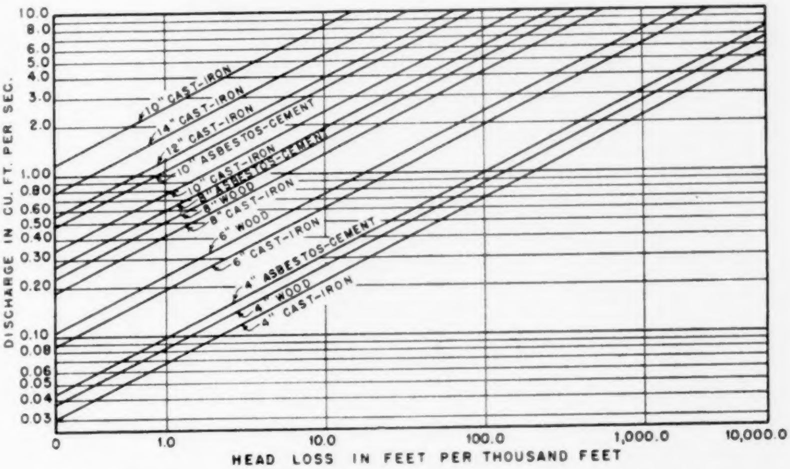

Fig. 2. Relation of Head Loss to Discharge of Various Types of Pipe

Often the correction as found by the Hardy Cross equation, if applied to one circuit, will throw the neighboring circuit further out of balance. Thus the flow correction found must, in most cases be modified by the condition existing in neighboring circuits.

By applying the system only to individual loops, a fairly close balance may be secured in the unit circuits, but the system as a whole may show unbalanced head losses. This difficulty may be overcome by applying the Cross equation to the major circuits, excluding all minor mains and laterals, after each correction to the unit circuits has been made. The correction found by the Cross equation for the major loop should be used to modify the correction found for each minor circuit.

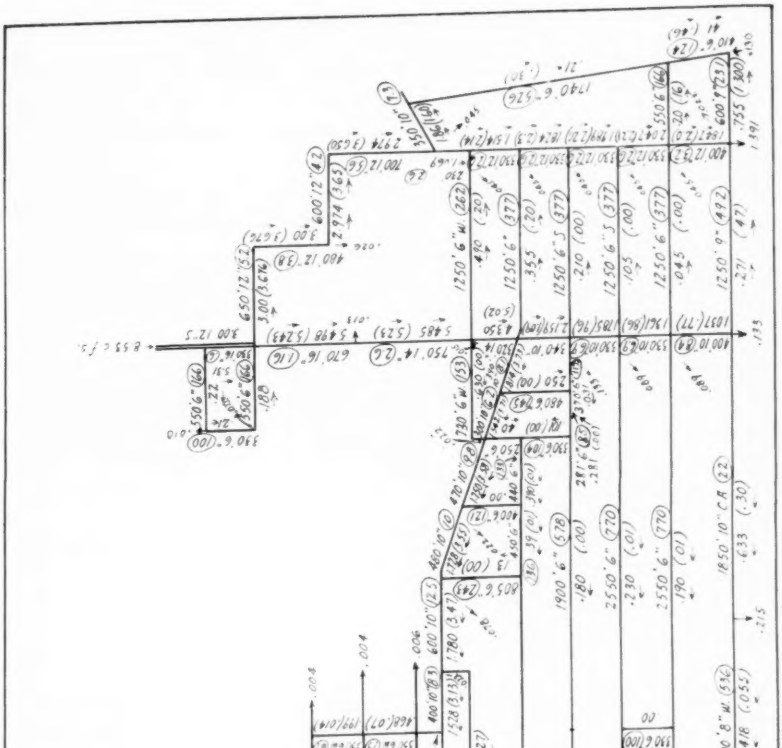

FIG. 3. Flow Analysis Record of Section 1; computed by the Hardy Cross Method

To check the corrections made, the head loss around each circuit should be found. In Fig. 2 the head loss in various pipes is plotted against discharge so that values of friction losses may be obtained easily.

Figure 3 illustrates the technique of recording the analysis on a map, showing Section 1 of the system to a reduced scale. The type of pipe is assumed to be cast iron unless otherwise noted on the map. Resistances are circled. The size and length of pipe are also marked on the plans. The initial flow estimates are shown in parenthesis, and the final flows are clearly marked with an arrow showing direction of flow.

Hydraulic gradients for the main circuits have been plotted in Fig. 4.

Distribution of Demand

The first problem connected with an analysis of a water works system is the determination of the maximum load likely to fall on the system. This load is divided into two main parts—the ordinary demand, and the fire demand.

As mentioned in the introduction, the actual pumpage into the Edmonton system has been practically constant for several years and will probably remain constant until the year 1943. An actual study of consumption data (1) reveals that the maximum rate on any day for a period of one hour is 18,000,000 gallons per day (Imp.). Industrial demand is 63 per cent of the total, leaving a maximum flow of 6,700,000 gallons per day (Imp.) for the domestic consumer. As only 50 per cent of the population lives on the south side, the maximum ordinary flow in the mains to the south side is about 3,400,000 gallons per day (Imp.).

There are two methods for distributing this flow. The more exact method would be to make a thorough survey of consumption in all the districts. This could be done as the Edmonton system is almost 100 per cent metered. Such refinement is, however, not warranted because of inaccuracies in the friction assumptions made for the pipes.

A much quicker and easier method is the one used in this thesis. The large consumers on the south side were tabulated and, from their meter records, the average daily flow for the maximum month was computed. This flow was converted to maximum peak demand by use of the factor 1.5 (probably conservative). The flow thus found was entered as a take-off at the location of each of the large consumers (Fig. 3).

From a map, the number of blocks served by the water system was determined. Dividing the remainder of the water consumption by this number, the average block water demand was found to be .022 cu.ft. per sec. This figure was modified to suit local conditions. The take-offs were made at the corners of the blocks.

For the fire demand, several possibilities were considered. The worst fire hazard is St. Stephen's College, a residence on the University of Alberta campus. In case of a fire in this building four fire streams of .555 cu.ft. per sec. would be available.

Adding the load due to the above possible fire to the maximum ordinary demand, the total demand on the systems totals 8.53 cu. ft. per sec.

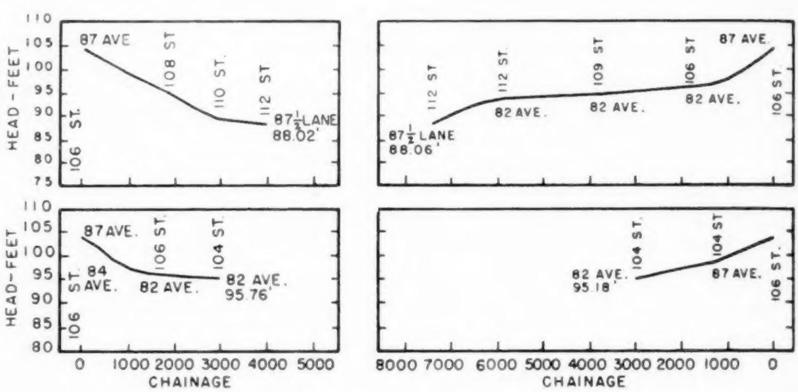

FIG. 4. Hydraulic Gradients of Main Pipe Lines

Pipe Used in the System

Because the water has a hardness of approximately 180 p.p.m. and is non-corrosive, very little trouble has been experienced from internal corrosion. Destruction of pipes has taken place due to the action of external forces. The interior surfaces in the majority of cases have been found in good condition when inspected.

Four general types of pipes are in use at present: wood stave, steel, cast-iron, and asbestos-cement. Cast-iron pipe is the most common of these four types. The first cast-iron pipe was laid in 1912 and has given very little trouble since its installation. All repairs made on this pipe have shown the interior to be in fairly good condition.

In 1909, the first water pipe was laid on the south side. This

pipe was wood stave. There is still a considerable length of this original pipe in the system. In some localities large leaks have been caused due to the spreading of the staves and the mains have been replaced. Every removal of wood-stave pipe has revealed the wood in perfect condition but the wire winding eroded through. From this it is safe to conclude that the interior surface is as smooth at the present time as it was when it was first installed.

Soil conditions in Edmonton make the life of steel pipe short. The first steel pipe was laid in Edmonton in 1912, the last section in 1930. As mentioned above, failure of metal pipe has been due almost always to external forces. The interior of the pipes usually has not been corroded. So it has been with steel pipe in the system. The interior of the pipe has been in comparatively good condition.

In 1934, the first asbestos-cement pipe was installed. At present

TABLE 1

Summary of Pipe Friction Experiments

PIPE	PIPE FRICTION COEFFICIENT	
	Williams & Hazen C	f
Asbestos-Cement	140	.013
Cast-Iron	100	.026
Steel	100	.026
Wood	120	.018

there is a total of 2.7 miles of this pipe in the system. Due to various objections to the use of this pipe in a distribution system, however, it is unlikely that it will be used extensively in Edmonton. The chief advantage of asbestos-cement pipe is the constancy of the value of the friction coefficient.

Friction Coefficients (2, 10–19). To make an accurate determination of friction coefficients, the interior of all the pipes must be examined or tested. This, however, was impossible, so approximations were made.

Numerous experiments have been made and numerous articles have been written on the coefficient of pipe friction (2, 10–19). Table 1 shows a summary of such experiments and gives the values of the coefficient of pipe friction estimated for the Edmonton water works distribution system.

Equivalent Pipes (2): In several locations along 82 Avenue, water

mains lie on each side of the street. To simplify the computations in the problem as much as possible an equivalent pipe was substituted for these two parallel lines.

The method used to compute these equivalent pipes was as follows:

1. A drop in head along the parallel system was assumed.
2. From this drop in head a discharge for each pipe was computed.
3. Using the same drop in head, a pipe that would have the same discharge as the total discharge of the two original pipes was estimated. This pipe was then the equivalent pipe and it was substituted in the network for the parallel system.

Development of Constants

There are a number of formulas relating loss of head to flow in pipes. These can be found in any good hydraulics textbook. The Williams and Hazen, the Chezy, and Scobey formulas are used probably more than any others. Several papers have been published using the Williams and Hazen formula in the solution of flow problems by the Hardy Cross method. For very accurate work the Williams and Hazen, Scobey, or Chezy formula should be used. These, however, necessitate the use of tables and special slide rules. For the average distribution system, where the friction coefficients of the pipe cannot be estimated to closer than 10 per cent, the increased labor entailed for accuracy is not warranted.

The general equation for flow in pipes given by Lea (20) is as follows:

$$h_f = f\frac{1V^n}{D^m 2g} \qquad (6)$$

Assuming $n = 2$, $m = 1.25$ and substituting $\frac{Q}{A} = V$.

$$h_f = f\frac{1}{D^{1.25}}\frac{(Q)^2}{(A)} \times \frac{1}{2g}$$

$$h_f = \frac{f}{2g} \times \frac{1}{\frac{\pi^2}{16}} \times \frac{1}{D^{5.25}} \times Q^2 \qquad (7)$$

The quantity of water flowing into the system is fixed. Therefore the constants, derived for use in the analysis of flow, do not need to

be absolute but only relative. As $\frac{\pi^2}{16}$ and $2g$ appear in the resistance equation for all pipes they can be dropped from the equation.

$$H_f \approx \frac{K1}{D^{5.25}} Q^2 \qquad (8)$$

$$h_f \approx rQ^2 \qquad r \approx \frac{K1}{D^{5.25}}$$

TABLE 2

Relative Values of $\frac{r}{1}$ for Various Types of Pipe

DIAMETER	$\frac{r}{1}$			
	Asbestos-Cement	Cast-Iron	Steel	Wood
in.				
4	1,455.0	2,525.0	2,525.0	1,745.0
6	173.9	302.0	302.0	209.5
8	38.2	66.3	66.3	45.8
10	11.9	20.8	20.8	14.4
12	4.6	8.0	8.0	5.5
14	2.0	3.5	3.5	2.4
16	1.0	1.7	1.7	1.2

TABLE 3

Comparison of Head Loss Values by Different Methods

PIPE	VELOCITY	DIAMETER	WILLIAMS & HAZEN COEFFICIENT	HEAD LOSS		DIFFERENCE
				W. & H.	Lea	
		in.				%
Asbestos-Cement..	1.60	8	140	1.22	1.23	1
Cast-Iron.........	1.84	10	100	2.29	2.45	6.5
Cast-Iron.........	4.05	14	100	6.70	7.80	14.0
Wood..............	2.05	6	120	3.60	3.90	7.7

Table 2 gives a set of relative values of $\frac{r}{1}$ for the various types and sizes of pipes used in the Edmonton problem. The resistance of 1,000 ft. of 16-inch asbestos-cement pipe was considered as unity. A comparison of values computed by Lea's formula, and Equation 8 values taken from the Williams and Hazen flow tables for head loss in 1,000 feet of pipe is made in Table 3. There is a close check at

low velocities, but as the velocity increases the difference becomes greater. The maximum velocity in the system is a little over 4 ft. per sec.; and there the difference is about 14.0 per cent. As this maximum occurs in only one locality, the check between the Williams and Hazen and Formula 8 is sufficiently close.

Having found the values of r for every pipe length in the system, the Cross expression was applied to the analysis of flow. With the value of $n = 2$, Equation 5 became

$$\Delta Q = \frac{\Sigma rQ^2}{\Sigma 2rQ}$$

Flow Distribution

The south side of the Edmonton water works system can be divided into four parts. Each of these parts can be analysed almost independently of the others. Because of this division, a general distribution of flow can be made by a knowledge of the demand localized in each division.

The first flow assumptions were made on the principle that the quantity of flow in each pipe varied with the square of the pipe diameter. After the first flow assumptions were made, successive corrections were made by means of the Hardy Cross method. A total of eight corrections was necessary to bring the whole system to a balance within 10 per cent.

Conclusions

From the analysis made, it appears that the system has been considerably overdesigned. The 8-inch main on University Ave. between 104th and 112th Sts. carries water in one direction for part of its length and in the other direction for the rest. The maximum velocity attained by the water is .60 ft. per sec., and the average velocity is about .20 ft. per sec. One 8-inch main has a head loss of 3.1 ft. in 5,200 ft., the water attaining a maximum velocity of .85 ft. per sec. Another 8-inch main has a head loss of about 6 ft. in 9,000 ft., the water reaching a velocity of 1.40 ft. per sec.

These 8-inch mains could be replaced by 6-inch mains, as the likely future demand in the districts they serve will either not increase or be served more efficiently by other mains.

The analysis made indicates that the 6-inch laterals used to serve the individual demands of residential blocks could be reduced to 4 inches. As a change in the location of the fire demand would alter

flows considerably, however, the 6-inch lateral is probably the size required for safe practice. The large mains carry nowhere near their capacity and will be of adequate size for considerable time in the future.

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Recent Problems and Developments in Michigan

By Raymond J. Faust

THE supervisory control of public water supplies in their relation to public health was given by law in 1913 to the Michigan Department of Health. Dr. R. L. Dixon, Secretary of the State Board of Health at that time, appointed Col. E. D. Rich to enforce the provision of the law, under the title of State Sanitary Engineer. One of the major problems confronting Col. Rich in his work was the safeguarding of public water supplies. How and what he accomplished is an open book and is a credit to him.

In retrospect, there appear to be four phases of the control work with public water supplies which were most significant:

1. Plans of all water supplies and distribution systems were obtained by the department in accordance with the law. They served as a basis for the study of each system and were therefore indispensable.

2. In 1916, the Michigan Department of Health adopted a regulation requiring, in effect, that all public water supplies that are treated must be under the control of a local laboratory, and that the results of tests be submitted to the department on monthly report forms.

3. At the request of the members of the Michigan Conference on Water Purification, a second regulation was adopted by the department in 1931. This required that persons in responsible charge of water treatment plants have their qualifications certified by the department.

4. The association of water plant operators called the Michigan Conference on Water Purification was organized eighteen years ago.

There are also certain associated factors. Three years ago the

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A paper presented on September 11, 1940, at the Michigan Section Meeting, Ann Arbor, Mich., by Raymond J. Faust, Assistant Engineer, Michigan Department of Health, Lansing, Mich.

Michigan Section of the American Water Works Association was established. A short course is now conducted annually by Michigan State College. This rounds out the program for the training of operators.

Today the results of the control program are evident. There are 61 local water supply laboratories supervising the quality of water used by 3,024,443 people in the state. This represents almost 85 per cent of the people served with water from public supplies. Even more significant is the fact that each of these laboratories is under the control of men whose qualifications have been certified by the Michigan Department of Health. Both the Conference and the Association, with their papers and the close contacts they afford operators, have helped materially in making these things possible. The short course has given basic training to many operators and has added an incentive to study and further self improvement.

In the state, there still remains a tremendous task of water conditioning, including softening, iron removal, and corrosion control. Metering problems are gradually being solved although much work remains, especially with the accurate recording of the smaller flows; and many leakage and corrosion problems confront the water distribution men.

Chlorination and Conditioning Plants

In Michigan the first city to chlorinate its water supply successfully was Menominee. The treatment with hypochlorite of lime was started on March 30, 1910, and continued until October 24, 1916, when the hypochlorite of lime was replaced by liquid chlorine. Since July, 1917, this supply has been both filtered and chlorinated. In 1911, Marquette followed Menominee's lead, and Battle Creek, Ludington, Port Huron, Ann Arbor, South Haven, and St. Joseph followed one year later. In 1913, the list was increased to include Alpena, Detroit, Gladstone, Grand Rapids, Marine City, Munising, Sibley Quarry, St. Clair and Traverse City. Subsequently some of these cities installed filters so that by 1939, 85.3 per cent of the urban population of Michigan was using chlorinated water, much of which was also filtered.

During the past year (1939–40), four towns started chlorination of their public water supplies. Holland and Zeeland are disinfecting ground water supplies while Lakeview and Eagle River are treating surface supplies.

Lansing and Ypsilanti recently placed lime-soda ash water conditioning plants in service. The plants, except for size, are quite similar. Both treat ground water and both are of the two-story type. It is of interest to note that the non-carbonate hardness of the Ypsilanti raw water varies as much as 78 p.p.m. in 24 hr. The average non-carbonate hardness is about 100 p.p.m., with a maximum of 145 and minimum of 67. The carbonate hardness remains practically constant at 270 p.p.m.

The reason for the variations in non-carbonate hardness is not definitely known but may be associated with pumping rates—low pumping rates producing water with low non-carbonate content. This refutes the popular idea that the chemical quality of ground water remain fairly constant.

Flushing and Mt. Morris installed zeolite softening and iron removal plants. The basis of operation is to soften and remove iron from a major portion of the water being pumped, while the smaller portion is treated only for the removal of iron. At Flushing, iron removal is accomplished by passing the water through a manganese zeolite filter which is regenerated with potassium permanganate. Oxidation and filtration are accomplished in the same unit. At Mt. Morris the iron is oxidized by applying compressed air to the water in one tank, and the iron precipitate is filtered from the water in an ordinary sand pressure filter. Both processes appear to work satisfactorily.

New Water Systems and Supplies

During the past year, sixteen new public water systems were installed. The towns involved were: Harrisville, Ellsworth, Beulah, Beaverton, Lexington, Frankenmuth, Hudsonville, and Sebewaing and the townships of Mt. Morris and Genesee in Genesee County; Bridgeport, Zilwaukee and Carrollton in Saginaw County; Troy and Waterford in Oakland County; Bergland in Ontonagon County; and Eagle River in Keweenaw County.

Most of these new systems represent the completion of federal aid projects started one or more years ago. It appears now that the widespread water works construction program that was enjoyed by the state during the past four or five years will be seriously retarded in the future because of the withdrawal of federal aid.

Grand Rapids, St. Charles, Howard City and L'Anse placed in use new water supplies. Of particular interest is the change made by

Grand Rapids in shifting its source of water supply from the Grand River to Lake Michigan. Going 31 miles for better water places a premium on quality. Without question, the city secured the best supply available and one which needs no softening. This is the first instance in the state where a town has gone a long distance for a satisfactory supply. Other towns have considered such a move, particularly those in the Saginaw River valley where the surface water is heavily contaminated by sanitary sewage and industrial wastes and where fresh ground water is not available.

St. Charles replaced a very unsatisfactory supply from the Bad River with a ground water supply. The new supply works consist chiefly of infiltration tile lines laid on clay beneath a 12-foot layer of sand.

Howard City now has an approved ground water supply replacing a raw supply from Tamarack creek. To secure the change in sources of supply it was necessary for the State Health Department to win a court decision. Investigations found five homes and two undertaker's parlors discharging septic tank effluent into the creek not more than two blocks upstream from the intake.

At L'Anse the supply now comes from Keweenaw Bay, an arm of Lake Superior. The old supply consisted of wells, a spring, and, for a time, the Falls River. The new supply is chlorinated.

Chemical Pollution of Ground Water

In July 1939, the department received a complaint from the superintendent of water of Lowell, concerning a change in the taste of the water supply. The supply is obtained from wells. The taste was salty and a chloride determination showed 785 p.p.m.

An investigation revealed that during the time from April to August, 1935, a "wild cat" oil well was drilled at a location approximately 3,000 feet up the Flat River valley from the city wells. The oil well was plugged about October 1, 1935.

In drilling the well, brine was encountered at two places, in each case under artesian head. Analysis of the brine showed a chloride content of 41,000 p.p.m. During construction and afterwards, until the well was plugged, the brine was permitted to flow into a nearby gravel pit from which it seeped into the ground. Apparently the formation at the gravel pit is connected to the stratum from which Lowell secures its water supply and, being at a higher elevation, forms part of the feeding area. Results of samples from July, 1939, to

June, 1940, show a gradual lessening of the chlorides. In June, 1940, the analysis showed 320 p.p.m. It will be interesting to follow this case to find out how long it takes the chlorides to pass the city wells.

How much time was required for the ground water to flow 3,000 feet could not be determined since the people did not notice or object to the change in mineral content until it affected the taste of the water. The time interval between the start of disposal of the brine in the gravel pit until the time the people objected to the taste of the water was approximately four years. By using these figures it may be calculated that the rate of ground water flow averaged 62 ft. per month, or 2 ft. per day, or 1 in. per hour. If this is true it would appear that the Lowell water supply will not be free of excess chlorides for three years.

This is the first case in the state, in recent years, where brine from oil wells has contaminated a public ground water supply. Many surface water supplies have been, and still are, affected but the problem is being corrected by disposal of the brine into other wells, thereby returning it to its source.

Algae and Crustacea

The winter of 1939–40 was notable because of its mild weather, particularly in the Upper Peninsula, and because of the luxuriant growth of algae in surface water supplies. Whether the one was the result of the other is not known.

At St. Ignace the water supply is obtained from the Straits of Mackinac through an intake, 365 ft. off shore in 12 ft. of water. The supply is chlorinated but not filtered. During the week before Christmas, 1939, large masses of algae were found in the shore well and were seen to continue coming in for three days. The concentration of algae that passed into the distribution system was sufficient to plug all the meters in town. No similar experience was known to any of the natives, and unfortunately, no specimens were collected for identification.

At Escanaba, the supply is from Little Bay De Noc and is filtered and disinfected. During December, 1939, the average filter runs dropped to 21 hr., and the shortest runs were 13 hr. The average filter runs for the year were 40 hr. Algae were the cause of the trouble.

At Ishpeming, the algae and worm infestation of the public supply was so bad that it was necessary for many people to filter the water

through cloth tied to the faucets. This supply is taken from several inland lakes.

The problem at Menominee was unusual and is still unsolved. In October, 1939, the water department received complaints about "bugs" in the water supply. Flushing the hydrants near the homes of the complainants provided temporary relief. This was followed by a city wide flushing program during which 125 hydrants were opened. A bag was tied over each hydrant outlet to collect specimens of the trouble makers. They were found in 25 of the hydrants, located near the outer portions of the system, but none appeared in the central portion of the system.

Specimens of the "bugs" submitted to the State Health Department laboratory were identified as *Phyllopoda*, or fairy shrimp. How they gained entrance to the distribution system has not been determined. It is known that numerous specimens were found in the coagulation basin and on the filters. It seemed improbable, however, that adults could have passed through the filters, but their eggs may have done so. An investigation of one of the two clear wells showed no cracks or openings by means of which they might have entered. The second clear well was not investigated, but it will be when the water consumption is reduced and the basin can be taken out of service without jeopardizing the service.

During the latter part of the winter of 1939–40 and during the spring and early summer of 1940, no further complaints were received; and even though the problem was not solved it was thought that the difficulty had been eliminated. In August, however, a complaint was received and in flushing a small number of hydrants in the neighborhood of the complainants' home, seven *Phyllopoda* were collected. Aid has been requested of the U. S. Public Health Service laboratory staff at Cincinnati.

Pollution Problem of Trenton and Wyandotte

One of the more serious public water supply problems in respect to public health concerns the treatment of Detroit River water after it receives the domestic sewage and industrial wastes from Detroit and adjoining communities. The water supplies in question are those of Wyandotte and Trenton. The Wyandotte intake is 1,650 ft. off shore and thereby avoids the most heavily polluted water, but even so the average coliform index on the raw water last year was 18,928.

Although Trenton is a few miles further downstream than Wyandotte, the raw water indexes are much higher because of the short length of the intake which ends at the channel bank in the zone of heaviest pollution, and because the Wyandotte district sewerage system, serving approximately 50,000 people, discharges into the river not more than two miles upstream from the intake. Coliform indexes of 1,000,000 are common—in fact, much more common than are those of 10,000. Last year the daily average index was 114,359.

Such conditions cannot continue indefinitely without the occurrence of some serious accident or mistake in the treatment of the water. The recognition of the problem, no doubt, was a major factor in the construction of the Detroit and Wayne County sewage treatment plants. The Wyandotte district plant was placed in service in October, 1939, and the Detroit plant during the latter part of February, 1940. At the present time, the Detroit plant is treating approximately 60 per cent of its ultimate load. Both plants provide primary settling and disinfection with chlorine. To date, as the data show, the sewage plants have aided very little in reducing the coliform indexes of the raw water at the Wyandotte and Trenton filteration plants. The coming year should, however, show decided improvements in reducing stream pollution and material reductions in the burden carried by these water plants.

Electrolysis

Five years ago the Village of Standish installed a safe ground water supply, and abandoned an unsafe creek supply. To obtain fresh ground water in adequate quantity, it was necessary that the supply be located to the west of the town. Fortunately, the ground was considerably higher to the west and by installing the supply near Sterling a sufficient head was available to provide a gravity supply. The water transmission line is 22,000 ft. in length, 8 in. in diameter and made of spiral-welded steel pipe. The right-of-way is in state highway M 76 and parallels a power line.

After only one year of service, leaks began to appear in the pipe and continued to increase in number so that the amount of leakage caused the supply to become inadequate for the town. A total of 500 repairs to the pipe line have been made to date.

A sample section of the pipe 4 ft. 9 in. in size, removed for inspection and study, had four holes, five near holes and eighteen other corrosion spots. In other respects, however, it was in good condition,

showing no effects of wear. A current measurement of 40 milliamperes was found passing through the pipe, and this, no doubt, was responsible for the holes and leakage.

Certification of Personnel

On May 16, 1940, 39 candidates took examination for certification as water plant operators. Three of the five candidates for Operator First Class certificates passed; 14 of the 21 candidates for Operator Second Class certificates passed; and 7 of the 16 candidates for Analyst certificates passed.

The total number of certified operators in the state is 133, divided as follows: 39 First Class, 44 Second Class, 6 Second Class Limited, and 44 Analysts.

The problem of securing better legal status for certification is still imminent. Some definite action toward the solution of the problem should be taken. Questions for consideration are:

1. Do we want legislative enactment of a law requiring certification?
2. Should we again join with the Michigan Sewage Works Operators to back a joint certification program?
3. Should we try for passage of a bill effecting only certification of water plant operators?

These and other questions must be answered, committees formed, and much ground work done before a legislative program may be undertaken.

Maintaining Water Service in Sub-Zero Weather

By Elwood Farra

MOST water companies in Kentucky and Tennessee experienced one of the coldest winters in their history in the winter of 1939–40. The Lexington Water Company was no exception. It was faced with the problem of maintaining service through meters and services which persisted in freezing.

Before relating the details of the experience, a description of Lexington's distribution system is necessary to a thorough understanding of the problem. The distribution system serves approximately 70,000 people through some 15,000 meters. There are 145 miles of mains which range from 2 to 24 inches in diameter. All services are metered and the meter settings are at the curb. Small meters are set in a round concrete meter box with a cast-iron cover, while larger meters are placed in a brick vault with a concrete-slab top and a cast-iron manhole cover. The small meters are placed in a copper setter which raises the meter to a point approximately 18 in. below the top of the meter box. Meters that are not set in copper setters have extension dials, the meter being located in the bottom of the box.

The service materials are either lead, copper tubing, or wrought iron for services up to $1\frac{1}{2}$ in. in diameter and cast iron for the larger sizes. All services average about 30 ft. in length and were originally installed with a 30-inch cover. A great many of them were installed a number of years ago under high-crown macadam streets and as the old type pavement was replaced by better pavements with a very low crown, the cover over some of the older services has, of course, been reduced.

The distribution system includes 834 fire hydrants of four different types: Holly, Matthew, Bourban, and Darling. They all have 4-

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inch valve openings and two $2\frac{1}{2}$-inch hose connections. All new hydrants also have $4\frac{1}{2}$-inch steamer connections.

In making a further study of the reasons for the unusual maintenance trouble in the distribution system during the winter of 1940, the writer has examined carefully the temperature records beginning with December, 1939, and extending through February, 1940. It was found that temperatures remained below freezing for a continuous period of 50 days, beginning December 21 and ending February 9. The condition was unusual for this section of the country where, though frequent, very cold weather usually lasts for only a few days. The continuous sub-freezing temperature caused the ground to freeze to a point deeper than at any previous time on record. During the time there were several snows but they did not help a great deal in providing a blanket over the services and meters because city ordinances require that the streets and sidewalks be cleared of snow and ice within 24 hours.

Another contributory cause was that the water in the reservoirs from which supply is obtained had a temperature of only 36°F. Thus, the temperature of the water had to be reduced only a relatively few degrees to result in frozen meters and services.

All of these conditions set the stage for a most unusual maintenance problem which, beginning January 4 and ending February 10, made it necessary for the maintenance crews to work day and night to maintain service.

Maintenance of Meters

The first meter froze on January 1, 1940. After that the number of frozen meters gradually increased from day to day till it reached a peak of 150 on January 29. The last meter froze on February 26. The situation was, however, handled without any special effort, except during the period from January 26 to February 7. During this time there were 1,002 frozen meters. A total of 1,360 meters, 9 per cent of the total in the system, froze during January and February.

To meet this emergency it was necessary to enlarge the maintenance crew by borrowing men from the farm crew, the pumping station and from the office. All of the cars and trucks belonging to the water company were used and several additional ones were rented, making a total of fifteen trucks operating on the work, each equipped with a large box of mineral wool, a bale of straw and a blow torch in addition to the regular tools.

When the truck crews were dispatched to the place of trouble, their first duty was to determine whether the trouble was with the company's meter or service or with the customer's water pipes. If the trouble was in the meter, it was removed and replaced with another one. The meter box was then packed with straw and mineral wool and the cover carefully replaced.

The ordinarily ample reserve of 200 to 300 meters was found insufficient to meet the emergency and, after a few days, it was found necessary to resort to a "jumper," to replace the meter. The "jumper" was a short piece of 1-inch pipe that was fitted between the meter couplings.

One reason why so many meters froze was that many people, when they found their water pipes frozen, opened the meter box to attempt to find out what the trouble was. In many cases the tops were not replaced properly, thus allowing the meter to freeze.

In addition, it was found that the continuous meter reading system led to many of the cases, in that, when the meter box lid was raised, the frost seal around the lid was broken, allowing cold air to enter the box. Because of this the meter reading was suspended for the duration of the cold weather.

A great many complaints, where the cause of trouble was in the customer's water pipes, were investigated. It is safe to estimate that during this time there were from 15,000 to 20,000 people, at various times, without water because their own plumbing was frozen. Realizing this to be an acute condition, the company began hauling water to all who asked for it. Several trucks were loaded with 5-gallon cans filled with water, taking all necessary sanitary precautions. These cans were delivered without charge.

Delivery of the 5-gallon cans was maintained for several weeks until such time as water service was restored. It was found necessary to limit each family to five gallons per day because there were so many requests that it was impossible to furnish more than this amount. The customers seemed quite appreciative of the service.

Maintenance of Hydrants

While not nearly so acute as meter maintenance, the maintenance of hydrants during the cold weather was also a considerable problem. It was necessary, for several weeks, to maintain constant inspections of the hydrants. Sulfuric acid was used to thaw the frozen hydrants.

The acid was poured into the hydrant* and as soon as it had burned out the ice, the hydrant was flushed, and then filled with a solution of radiator alcohol to prevent its freezing again.

Another item of maintenance of hydrants that caused considerable trouble was the moisture that seeped in around the packing and froze, making it impossible to open the hydrant. To remedy this condition, penetrating oil was put in the stuffing box and then a very stiff grease was packed around the stuffing box nut to prevent the recurrence of moisture in this part of the hydrant. The method was found to be quite effective and the hydrants that were repaired in this manner operated satisfactorily thereafter.

All hydrants were kept operative, so that at no time during the cold weather did the fire department report a frozen one. To maintain this service it was sometimes necessary to work men all day and all night on hydrant inspection. The inspection was made by "stringing" the hydrant, that is dropping a string with a weight on the end of it into the hydrant barrel through the nozzle. All hydrants that drain properly have about four inches of water standing in the bottom of the barrel up to the drain outlet. When the string showed this small amount of water standing below the drain it was certain that the hydrant was not frozen. The inspector would then try the operating nut with a hydrant wrench to be certain that the stem was not frozen in the stuffing box space.

Another precaution taken in regard to hydrant maintenance was that of limiting the use of the hydrants during the cold weather. Ordinarily, the hydrants are used for flushing sewers, washing streets, and in some construction work. To assure constant availability for fire protection, however, their use for other purposes was not permitted until the cold weather had abated and the ground had thawed.

Whenever the fire department uses a hydrant during the winter months a report, showing its location, is prepared. Each day, one of the maintenance men calls at the fire department for these reports, and then goes to the hydrant to make certain that it has drained properly and that it is in good operating condition.

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*Soft drink or beer bottles were filled with 66-degree acid and closed with rubber stoppers. On the job, the stopper was removed, the neck of the bottle inserted in the opening and its contents poured into the hydrant. The acid quickly drained out into the hydrant barrel. If breakage occurred, any bits of broken glass were driven out when the hydrant was flushed.

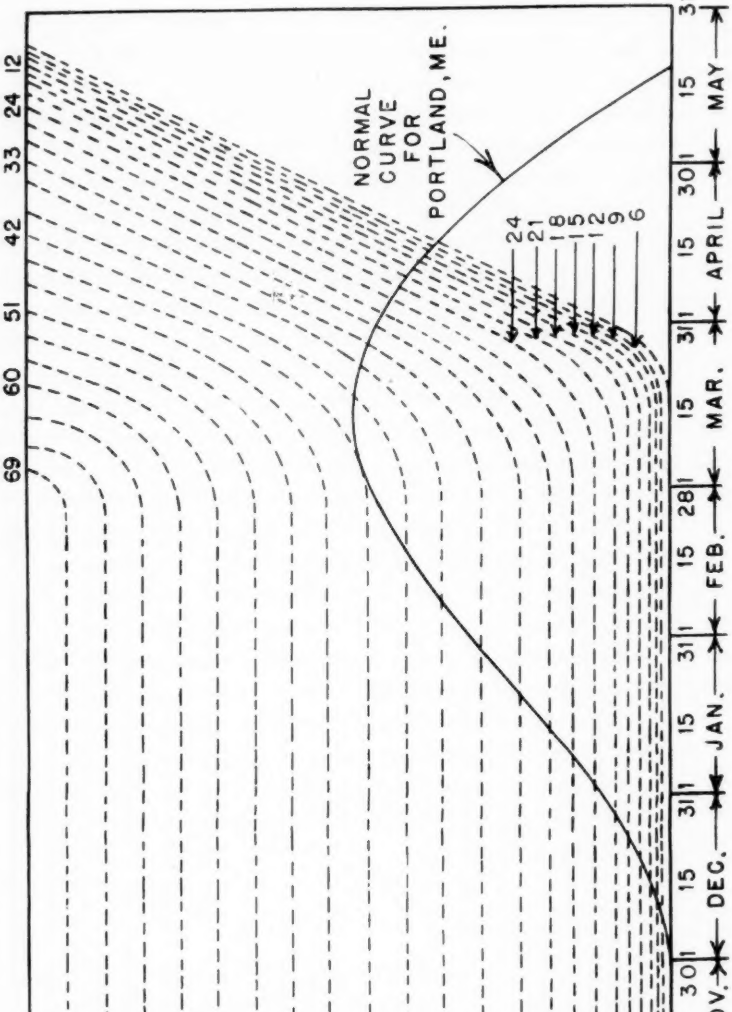

FIG. 1. Diagram for Determination of Probable Frost Penetration; reproduced by permission of Harry U. Fuller

While frozen meters were quite a problem, it was not nearly so difficult to restore service by replacing a meter as it was when the service pipe was frozen. There were, in all, a total of 292 frozen services during a period from January 4 to February 7—the largest number being on January 30, when 55 services were reported frozen.

Services were thawed by the use of a portable electric welding machine. In the method, the operator of the electric welder attaches one connection to the curb stop in the meter box and the other connection to the curb stop in the next closest meter box. The machine operates with a high amperage and a low voltage and thus heats the frozen service pipe. The technique is usually quite successful and ordinarily a service is thawed in a very short time, though at times, it took several hours to thaw a single service.

The most vexing part of the thawing work was the fact that the same service often froze several times, the frozen ground around the service refreezing it in a very short time. Because this happened several times, customers, whose services had been thawed, were always instructed to allow the water to run constantly in a small stream at some faucet in the house. No charge was made for this wasted water, and when the customer cooperated by allowing the water to run, it was not necessary to thaw out the service a second time. In a number of places, the water was allowed to run for several weeks in this way, but wasting water was much cheaper than thawing the service time and again.

Another item of interest in this connection is the record of pumpage during the cold weather. Normal pumpage for winter months is between 5 and 6 m.g.d. Records, beginning January 2, show that the pumping increased gradually until, by February 3, it reached a peak of 9.1 m.g.d. This represents an increase of 50 per cent, all of which was caused by excess leakage and wasting of water by the customers in order to keep their water pipes from freezing. It is also known that many people allowed their water to run constantly to avoid paying a plumber's repair bill. It was not until March 1 that the pumping rate returned to normal.

Finally, after the emergency had passed, the problem of repairing some 600 meters that had accumulated remained to be solved. In some cases this could be done merely by replacing the meter bottom. There were, however, a large number of meters where the meter case was sprung out of shape making it impossible to bolt on a new bottom. To overcome this difficulty, the meter repair man worked out an ingenious scheme of springing the meter cases back into shape.

He made a steel die which fitted in the base of the meter case. The sprung case was placed in a rigid frame and the steel die was forced against it by the use of a 25-ton hydraulic jack. By this method he was able to straighten the meter cases at a very small cost and to return the meter to service in good condition without the necessity of replacing the old case.

Cold Weather Precautions

A similar cold winter in 1936 gave the staff some experience which proved extremely valuable in handling the problems which arose last winter. Other than the experience of the staff, however, such measures as the preparation of maintenance equipment, thawing apparatus and the stocking of an adequate supply of repair material are important to successful maintenance of service.

An additional aid to meeting the problems of cold weather is the use of a diagram for the determination of frost penetration which was recently developed by Harry U. Fuller, Chief Engineer of the Portland Water District, Portland, Me., and described in the *Journal of the New England Water Works Association* for September, 1940. By use of the diagram, it can be determined when penetration of frost will be deep enough to threaten the meters or services of the distribution system. Application is made by plotting the normal curve of accumulated temperature deficiencies against the given depths of frost penetration.

The accumulated temperature deficiency is determined by subtracting the mean air temperature during the day from 32 degrees and by adding the remainder to the sum of the deficiencies of the preceding days recorded. Records are kept from some time before the earliest frost until all frost is out of the ground—from November to June in the case of Portland. A normal curve can then be determined from the deficiency curves of a number of years. When this normal curve is plotted on the diagram, probable frost penetration depths for any particular dates can be read directly, as in the example (Fig. 1).

This particular diagram may not apply to the soil in a given territory, but the method is certainly worth trying.

In conclusion, the author would like to point out that although the experience of last winter tried to the utmost the abilities and resources of the men involved, it also was valuable, since, through necessity, they learned in a short time how to handle New England weather in a distribution system designed for Kentucky winters.

Radio Directed Water and Sewer Service

By K. F. Hoefle

FOR many years the City of Dallas has operated an emergency, or, as it is called by the workmen, "stopped sewer," truck. The truck, operated by an experienced "trouble shooter" and two helpers, is on duty every day of the year and is subject to call at all hours. About 5,000 complaints per year, ranging from bad odors, from any and all causes, to appeals for the rescue of jewelry or small pets from the sewers, are disposed of by the crew.

Formerly, it was the practice of the driver of the truck to call his office after the disposal of each complaint to report what he had found and what remedy had been applied and to pick up any additional calls that might have come in. Only on rare occasions did he drive back to the shop in search of work to do. During rain storms, when infiltration overcharged the collection system, the crew was swamped with calls and usually had to be relieved and assisted by additional maintenance men.

Sometimes, under the system of reporting and assigning calls by telephone, real distress calls had to remain unanswered for a considerable time because there was no way of reaching the crews in the field; and often these delays resulted in considerable damage by flooding.

It was with the hope of rendering faster service and of cutting down such damage that the sewer complaint truck was first equipped with a police radio in June, 1937. Though the radio call is not resorted to on all complaints, results have been most gratifying in its use at times when damage to property is being done or when such damage is imminent.

A paper presented on October 16, 1940, at the Southwest Section Meeting, Tulsa, Okla., by K. F. Hoefle, Distribution Engineer, Dallas City Water Works, Dallas, Tex.

Equipment

The radios used are police-type short wave receivers. They are tuned to receive only KVP signals, the tuning knob being removed from the set. At all times when the truck is away from the shop, whether in motion or standing by, the radio is alive and ready to pick up any message. To put out a call, the department clerk must only phone the announcer of the Dallas Police Radio Station, KVP, who broadcasts the request, "Car Number 540 call your office." In the course of from one to three minutes, the reply is received by telephone and the man is given his instructions.

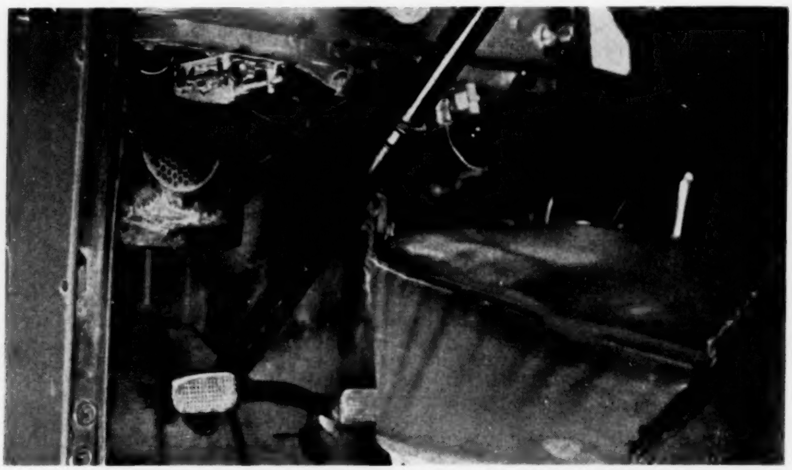

FIG. 1. Installation of Short Wave Receiver in Service Truck

Since 1937, six other units have been supplied with radios—three in the sanitary sewer maintenance and three in the water distribution maintenance service. One of these cars is driven by the distribution engineer and one by the assistant superintendent of sewer maintenance. Thus, it is possible to reach, by radio, anyone needed for any kind of an emergency.

Results

One of the most important results of the use of radio calls has been the customer good will gained by the speedy action on complaints. Often, the speedy arrival of the emergency truck results in relieving a condition that might otherwise cause great damage or inconvenience,

but even when all possible damage has been done before the report is received, the prompt arrival of the emergency crew to unstop a sewer and to clean up the premises has had an important effect in cooling down the resentment caused by the difficulty.

Numerous expressions of appreciation and gratitude have been received for the promptness with which the emergency crew has been able to reach the scene of trouble since the radio directed system has been in operation. The following examples, taken from the records, are typical of the speed of service given:

"*June 20, 1940.* Perkins Dry Good Company telephoned at 11:05 A.M. that sewer was backing into basement, threatening to flood them. Truck driver answered radio call at 11:08 and reported back at 11:22 that the stoppage had been cleared with but slight flooding of basement and no damage to goods."

"*July 11, 1940.* Drug Store, Oakland and Grand. Complaint received 9:27 A.M. Driver answered radio call at 9:30 and reported back at 10:00 that stoppage had been cleared. No damage."

"*September 26, 1940.* Cafe, 1300 Main. Complaint received 11:35 A.M. Driver answered radio call 11:38 and reported back that stoppage had been cleared at 11:44. No flooding."

The last case was a little unusual in that the emergency crew was working at a nearby address and so was able to give the call immediate attention, but it is indicative of the benefits that can be derived from the radio call.

One of the radio-equipped trucks is that used by the valve service crew. This crew of two, and sometimes three, men makes all valve shutdowns to allow connections to the system by construction crews and opens the valves after work has been completed. No one else, except in an emergency, is permitted to operate a main line valve other than one shutting off only a dead-end main. In all cases of emergency, such as main breaks, the crew is called by radio to close valves necessary to isolate the break and, at the same time, a repair crew is dispatched to the scene to begin repairs. Without the radio, it would not be possible for one crew to take care of this job in a system as large as that of Dallas.

Cost

In the light of its benefits, the cost of the equipment is modest. It is necessary that the truck be equipped with a high output generator and a large capacity battery. When so equipped, however, but

little battery charging is required. The whole cost of the equipment is about $75 per truck. In Dallas, the total investment is approximately $500 and maintenance costs have been less than $20 per year. The police radio station has been glad to cooperate by putting out the calls with no charge for the service.

Future Program

During the coming year it is planned to equip two other units to round out the service offered. One of these installations will be made on the truck driven by the night service man who makes customer turn-ons and cut-offs on requests received at the main office at too late an hour to be taken care of by the regular force, and who makes first-hand investigations of all types of complaints. When the truck is radio-equipped, it will be possible to relay work to him in the field, thereby avoiding much back tracking and saving time.

The other truck to be equipped is that driven by the leak detector crew. This crew is at work on systematic leak surveys for the greater part of its time. Frequently, obvious leaks are repaired without location by the crew. The radio installation will be valuable, however, in making the crew available for the location of leaks, the exact positions of which are in some doubt. The use of the leak detection equipment in these cases will make possible exact location and therefore a single pavement cut.

After three years experience in Dallas, the department looks upon its radio installations as an unqualified success. Since most cities now have police radio stations, they can readily avail themselves of this adjunct to their service; and once tried, it will never be dropped. The author looks forward to the day when the radio will be just as indispensable a tool as any other in the equipment of a service truck.

The Use of Copper and Brass Tubes

By Carter S. Cole

THE corrosiveness of potable waters is subject to considerable change over a period of time due to the introduction of new purification methods and to the development of additional sources of supply to meet the constantly growing requirements of many communities. Consequently, many waters which may be considered only moderately corrosive today may be very corrosive a few years from now. With regard to the corrosive character of water supplies and the selection of plumbing materials, waters may be divided roughly into three groups.*

1. The first group includes waters only slightly corrosive to plumbing materials. These waters are characterized by high carbonate hardness (over 120 p.p.m.) and low free carbon dioxide content. Red brass or copper pipe is preferred for hot water lines. Yellow brass should be satisfactory and give long life on the cold lines.

2. The second group of domestic water supplies is moderately corrosive to plumbing materials. It is characterized by a carbonate hardness of 60 to 120 p.p.m., a free carbon dioxide content of 5 p.p.m. or less, and a pH not lower than 6.7. For this group of water supplies red brass or copper pipe is preferred for both hot and cold water lines. Most of the treated municipal water supplies are included in this group.

3. The third group is corrosive and is characterized by a carbonate hardness of less than 60 p.p.m. It includes extremely soft waters, high in free carbon dioxide. Spring and artesian well waters are apt to fall into this class. Red brass pipe gives the best service for this

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A paper presented on May 22, 1940, at the New Jersey Section Meeting, Trenton, N. J., by Carter S. Cole, Engineer, Copper & Brass Research Association, New York.

* These groups follow the classification for hardness given in the Geological Survey Water Supply Paper 658 of the U. S. Department of Interior.

type of water supply for both hot and cold lines. There is a growing tendency on the part of water companies to treat softer waters with lime or soda ash to neutralize the free carbon dioxide. This often results in leaving the water highly alkaline. For such waters, red brass is also preferred.

Untreated waters of this third group may cause green staining with the use of copper alloys, or rusting and red water if iron or steel is used. In the case of green staining with copper alloys, very small traces of copper are dissolved by the water, and the dissolved copper forms an insoluble product upon evaporation from slow dripping or upon contact with a soap film. While these stains are inconvenient, they do not indicate that the life of the pipe is seriously affected and they are perfectly harmless because the amount of copper in solution in the water is much too small to be in any way dangerous to health. Green staining can be prevented or avoided by either of two simple methods. For new installations, tin-coated red brass pipe or tin-coated copper should be used.

As an alternative, the water supply may be treated with marble or limestone chips, lime or soda ash, or by one of several commercial systems of water treatment to remove the aggressive corrosive agent, the free carbon dioxide. The use of marble or limestone chips placed in a suitable container to act as a filter for the water is the most economical and convenient method of treatment and has proved very satisfactory for cases of green staining occurring not only in this country but in England and Germany. It should be noted that this type of water, which may cause inconvenience with the use of copper or brass, is likely to give even more trouble if other common metals are used.

Regardless of local water conditions, "Type K" copper water tube, copper pipe, or red brass pipe is recommended for water service lines. If rigid pipe is used, it should be laid with regard to proper compensation for expansion and for the shifting of the earth in which it is placed. In underground work, pipe and tubing are subject to corrosive attack from both within and without, and red brass and copper are, in general, satisfactory for all soil conditions except cinder-fill or salt marshy soils. For these corrosive soils the pipe or tubing should be protected by painting with asphalt paint and wrapping with heavy burlap or wrapping paper. It is also desirable to backfill around the pipe with clay or clean sand mixed with lime. Other materials that are suitable for this purpose are limestone or broken plaster, if they happen to be available.

TABLE 1*

Manganese, Copper and Iron Content of Serving Portions of Foods

FOOD	MEASURE		Mn	Cu	Fe
	Serving	Weight edible portion†			
		grams	*mg.*	*mg.*	*mg.*
Apples	1 medium	100	0.04	0.10	0.60
Asparagus	5 large stalks, 8 in. long	100	0.10	0.14	0.79
Bananas	1 medium	100	0.82	0.21	1.76
Beans, string	½ cup, cooked	70	0.14	0.07	0.65
Beef, lean	Slice, 4 in. x 1½ in. x ¾ in.	114	0.02	0.11	4.45
Beef, liver	Slice, 4½ in. x 2½ in. x ½ in.	100	0.25	2.15	8.30
Beets	⅔ cup, cooked	100	1.35	0.19	2.36
Bread, white	1 medium slice	25	0.08	0.09	0.23
Cabbage	½ cup, raw shredded	42	0.03	0.02	0.14
Calf liver	Slice 4½ in. x 2½ in. x ½ in.	100	0.32	4.41	5.40
Chicken	3 slices, 4½ in. x 2½ in. x ¼ in.	120	—	0.39	0.99
Chocolate, bitter	1 square	28	0.90	0.75	0.88
Currants	¾ cup	100	0.31	1.12	0.70
Duck	3 slices, 4½ in. x 2½ in. x ¼ in.	120	0.04	0.49	2.05
Eggs	1 egg	50	0.02	0.12	1.26
Fish	Piece, 3¾ in. x 2½ in. x ¾ in.	110	0.02	0.27	0.63
Goose	3 slices, 4½ in. x 2½ in. x ¼ in.	120	0.06	0.40	2.42
Lamb chops	2 small	96	0.04	0.40	3.20
Milk	1 cup	240	0.005	0.04	0.58
Mushrooms	½ cup	100	0.05	1.79	3.14
Oatmeal	½ cup, cooked	25	0.70	0.13	0.95
Oysters	4 to 8(⅓ cup)	110	0.24	3.38	3.45
Peas, green, shelled	⅔ cup	100	0.42	0.24	1.77
Peas, split	⅔ cup, cooked	50	1.39	0.70	2.85
Pineapple	1 slice	65	0.70	0.05	0.21
Pork chops	1 large	54	0.03	0.17	0.82
Spinach	½ cup, cooked	100	0.70	0.12	6.60
Shredded Wheat	1 biscuit	27	0.65	0.17	1.22

* Parts of table reprinted with permission of The Journal of the American Dietetic Association (1). See original table for more complete list of foods.

† Fresh or undried.

In many sea-coast localities, pipe is installed to provide circulating salt water for baths and pools. For such salt water plumbing, red brass and admiralty pipe have proved to be very satisfactory.

It seems peculiar that so many people who think nothing of finding a little rust in their water become highly alarmed when they find a faint green tinge in it due to a very minute copper content. In this connection it is quite interesting to note the amount of copper that we get in our daily food. Tables 1, 2 and 3 give the amount of copper in serving portions of various foods. In a single meal, one may eat 0.5 mg. or more of copper, an amount comparable to that found in the most corrosive of waters when untinned copper tubing is used.

TABLE 2*

Daily Intake of Manganese, Copper, and Iron of Various Types of Individuals

INDIVIDUALS	MANGANESE	COPPER	IRON
	mg.	*mg.*	*mg.*
Child one and one-half years	1.16	0.69	7.00
Child three to four years	.80	.63	4.50
Child five to six years	3.52	1.73	16.69
Child ten years	3.43	1.86	13.86
Boy sixteen years	7.46	3.01	21.17
Girl sixteen years	2.86	1.74	13.45
Sedentary man	3.79	1.89	13.56
Sedentary woman	2.03	1.39	15.73
Working man	8.41	4.81	36.12
Active woman	1.91	1.76	13.31
Family, summer, No. 2	1.29	1.73	12.06
Family, summer, No. 4	2.32	2.14	9.88
Family, summer, No. 6	3.00	1.85	13.39
Family, winter, No. 1	2.51	1.86	21.72
Family, winter, No. 2	2.29	1.68	18.60
Family, winter, No. 6	2.94	4.27	16.97
Family, average	2.39	2.26	15.44

* Data from The Journal of the American Dietetic Association (1)—reproduced by permission.

At the University of Wisconsin, it has been calculated (1) that an active working man can, in his diet, regularly eat 4.81 mg. of copper per day without ill effects. Again it has been shown that a serving portion of oysters contains about 3.38 mg. of copper, and yet some people who eat oysters regularly are worried by the copper content of slightly tinged water.

The U. S. Public Health Service (2) limit of 0.2 p.p.m. of copper is quite generally recognized today as being extremely conservative. Dr. Sidney S. Negus, in a paper published in the JOURNAL (3) points out that a person drinking two quarts of water a day (the average intake) with this much copper in it would be getting only approximately 0.4 mg. of the substance. The body requires at least 2 mg.

TABLE 3*

Contributions of Various Classes of Foods to the Manganese, Copper and Iron Content of Diets—Percentage of Total Intake

INDIVIDUALS	VEGETABLES	FRUITS	CEREALS	MILK	EGGS	MEATS	OTHERS
Manganese:							
Child 1½ years	15	2	80	1.6	1.4	0	0
Child 3-4 years	5	2	90	2.2	0.2	0	0.6
Child 5-6 years	45	3	51	0.4	0	0	0.6
Child 10 years	16	3	78	0.5	0.1	0.2	2.2
Boy 16 years	5	18	71	0.3	0.1	0.1	5.5
Girl 16 years	13	17	57	0.4	0.2	0.5	11.9
Sedentary man	34	2	56	0.2	0.7	1	6.1
Working man	17	16	61	0.1	0.02	0.3	5.6
Family, summer	15	21	42	0.8	1.3	0.7	19.2
Family, winter	13	43	33	0.7	0.2	6.6	3.5
Average	18	13	62	0.7	0.4	0.9	5
Copper:							
Child 1½ years	14	7	49	20.3	9.7	0	0
Child 3-4 years	12	7	58	20.6	2.4	0	0
Child 5-6 years	37	12	45	6	0	0	0
Child 10 years	21	15	38	6	2	2	16
Boy 16 years	11	15	40	4.7	1	2.1	26.2
Girl 16 years	20	19	34	3.8	2.6	5.4	15.2
Sedentary man	31	7	26	3.4	10.2	14.7	7.7
Working man	21	9	28	1.8	0.3	3.3	36.6
Family, summer	19	11	21	7	15.2	6.3	20.5
Family, winter	7	8	9	3.3	1.1	63.3	8.3
Average	19	11	35	7.7	4.5	9.7	13.1
Iron:							
Child 1½ years	24	6	21	31.7	17.3	0	0
Child 3-4 years	8	14	28	46.3	3.5	0	0.2
Child 5-6 years	59	12	18	10.2	0	0	0.8
Child 10 years	20	20	24	13	3	10.4	9.6
Boy 16 years	10	17	34	10.6	1.5	11.4	15.5
Girl 16 years	14	24	21	9.6	3.8	22.1	5.5
Sedentary man	38	7	22	7.4	15.1	6.4	4.1
Working man	24	11	22	3.9	0.5	17.3	21.3
Family, summer	27	11	13	15.3	23.2	4.2	6.3
Family, winter	14	15	12	13	2.3	34.1	9.6
Average	24	14	21	16.1	7	10.6	7.3

* Reprinted with permission of The Journal of the American Dietetic Association (1).

a day, so 0.2 p.p.m. of copper is probably helpful, certainly not harmful. The Water Works Commission in the Netherlands (4), after a careful review of all the work on the subject, came to the conclusion that 3 mg. per liter, that is 3 p.p.m., would be permitted in water that had stood for 16 hours, and 2 p.p.m. in water that was running. The whole point is that disagreeable stain from the copper pick-up occurs long before the amount of copper can in any way be injurious to health. Small amounts of copper are beneficial to health and are used in medicine today, particularly in the treatment of anemia.

The waters that will pick up small amounts of copper are few and far between. They are mostly on private supplies, as very few public supplies today are corrosive enough to do that. A few waters along the eastern seaboard are soft and high in CO_2, but they can be handled, with present knowledge, by two methods. One is by treating the water to tie up the CO_2 as bicarbonate, so removing its aggressive character; and the other is through the use of tinned copper tubing. When water is treated by a water company, lime is probably the most economical way to handle it; but for private supplies, marble or limestone chips are much better and quite effective.

The author has had personal experience with a water with a pH of 4.7, a hardness of about 16 p.p.m., and a free CO_2 of 27 p.p.m.—a rather aggressive water. This water picked up 5 p.p.m. of copper from untinned copper tubing. A small marble chip installation similar to that used near Harrisburg, by Glace (5), and to that reported by Cox (6) completely cured the trouble and eliminated all copper pick-up. That was five years ago, and the method is still completely effective.

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ABSTRACTS OF WATER WORKS LITERATURE

Key. **31**: 481 (Mar. '39) indicates volume 31, page 481, issue dated March 1939. If the publication is paged by issues, **31**: 3: 481 (Mar. '39) indicates volume 31, number 3, page 481. Material enclosed in starred brackets, **★[ ]★**, is comment or opinion of abstractor. Initials following an abstract indicate reproduction, by permission, from periodicals as follows: *B. H.—Bulletin of Hygiene* (*British*); *C. A.—Chemical Abstracts; P. H. E. A.—Public Health Engineering Abstracts; W. P. R.—Water Pollution Research* (*British*); *I. M.—Institute of Metals* (*British*).

CROSS-CONNECTIONS AND PLUMBING

An Analysis of 800 Plumbing Codes. Robert Dick. Plumbing & Heating Bus. **3**: 3: 16 (Oct. '40). Investigation aimed at 3-fold purpose: to show what has been done, what should have been done and what should be done to bring codes up to modern standards. Report covers over 800 cities of more than 10,000 pop. each—total of 41,000,000 pop.—but excludes N. Y. C. and Chicago whose tremendous pops. would distort figures. Statistics of codes figured on pop. basis. Only 28.4% of city codes (excluding state provisions) passed before '31 have been revised. Even taking state provisions, which, in effect, change local codes, into consideration, 39% of pop. still functions under codes passed prior to '34. Present status of codes shows 14 states with minimum rules on plumbing installations; 3 with rules whose application is not yet determined; and 8 with no rules, but which require boards of examining plumbers as well as licenses. 28 states have no regulations whatever, though 4 of these are now working on them. Codes administered by variety of authorities, but health depts. have wide majority of control (Table 1). At present date, 97.5% of codes require master plumbers' licenses, 75.1%, jour-

TABLE 1

Health Dept.	64.7%
Bldg. Dept.	13.2
Public Works	1.7
Water Dept.	0.5
Public Safety	1.3
City Council	0.5
City Engr.	0.6
Miscellaneous	1.0
Plumber's Board	0.003
No definite jurisdiction	16.5

TABLE 2

By civil service exam.	9.5%
By any exam.	5.2
Health Dept.	9.1
Bldg. Dept.	0.9
Water Dept.	0.3
City Mgr. or Mayor	5.9
Miscellaneous	3.3
No provision	74.8

neymen's licenses. Of these, 94.5% of licensed master plumbers must pass exams. and 99.0% of journeymen. Codes not as strict for inspectors—only 5.2% must pass exams.—and they vary in experience required of inspector—0.5% requiring 3 yr.; 4.6%, 5 yr.; 2.1%, 6 to 9 yr.; 6.7%, 10 yr.; 8.1%, merely that they be experienced or practical plumbers; and remaining 78%, no stipulated experience. Appointments of inspectors are made as shown in Table 2. Report also covers 74 of more important code provisions under 5 headings: (1) Materials—dealing with water closet connections, shower pans, roof flashing, traps, etc.; (2) Venting; (3) Protective requirements—dealing with cross-connections, prohibited by 50.9% of the codes, and pressure relief valves for boilers, required by 51.7% (in addition, noted that 44.0% prohibit frost-proof closets; 69.1%, hopper closets; 2.5% tapped tees; 68.3%, saddles and bands; 68.6%, double hubs in soil and waste lines and 1.7%, running threads); (4) Specifications; and (5) Inspection and Tests. Each of these sections analyzed statistically in regard to distribution of various types of requirements; and recommendations are made for what model code should include under each section.—*Ed.*

Safety Devices on Domestic Hot-Water Supply Systems. F. M. Dawson and A. A. Kalinske. Plumbing and Heating Bus. **2**: 8: 21 (Mar. '40). Explosions of hot-water heating tanks occur quite frequently with resultant property damage and loss of life. To protect against such hazards, understanding of some of physical changes that water undergoes, when heated, is necessary. Water has max. density at about 40° F. and expands if temp. is raised or lowered. 30 gal. of water at 70° F. will become 30.47 gal. at 160° F. Since water is incompressible, extra vol. must go somewhere. If container has no outlet, must stretch and perhaps burst because of stretching. No damage would occur unless temp. of water had exceeded 212° F. Pressure increases boiling point, and allows absorption of more B.t.u.'s of energy per lb. of water than needed to bring 1 lb. to boiling point at atmos. pressure. When tank bursts, extra B.t.u.'s. of energy cause portion of the water to flash into steam, which occupies 1,700 times as much space as same weight of water. Action furnishes energy that causes explosions and resulting damage. Excess pressure may be relieved by backing up into cold-water supply pipes, with consequent damage to meters if hot water reaches meter. Excess vol. in 30-gal. tank referred to will fill about 30′ of ½″ pipe. Check valves are sometimes used to limit backflow and to protect meters. This creates closed system which will allow high pressures to be built up if not relieved. Pressure relief valve should be installed on every hot-water supply system, even if check valve is not used. Damaged meter or closed valve may result in closed system. Most states have laws which make relief valves mandatory. Most pressure relief valves have spring-loaded disc, which may be set for different pressures, usually 15 to 20 lb. above normal static pressure. Valves should be in cold-water line to keep out hot water and to prevent consequent corrosion and lime deposit which would hinder proper action of valves. Vacuum relief valves are important for copper tanks and may be incorporated in pressure relief valves. All hot-water tank explosions occur because of overheating of water. If water temp. never reaches 212° F., explosion will never occur.

30-gal. tank referred to, with 75 lb. pressure, can reach 320° F. without formation of steam. If tank bursts at 320° F., about 3 gal. of water will flash into steam, occupying 570 cu.ft. of space. Energy released would exceed that produced by lb. of dynamite. Only method to protect against explosions from over-heating is to prevent excess temps. Thermostatic controls quite successful. One common type of temp. relief device has fusible plug of metal that melts at 212° F. Requires servicing after each use and age may change action of fusible plug. Bimetallic discs or elements are used in other types to open valve and to reclose at lower temp. There is a chance for such valves to stick closed. Only valves of best design and construction should be used, properly installed and regularly examined. Advisable to have temp. relief valve even if controlled heat source is used. Temp. and pressure relief features are sometimes incorporated into single valve. Temp. relief valves should be installed at point of max. temp. and should be rated in terms of B.t.u. capacity. Same size valve cannot be used on both a 30- and 500-gallon tank. Valve must be sized to discharge water fast enough to prevent any further temp. rise with burner going at full capacity. Pounds of water per minute discharge is equal to B.t.u. capacity of heater plus minute, divided by difference between 212 and cold water temp. Capacity of a valve will increase as static pressure increases. Mfr. should publish rating for each valve under various pressures. Further condition is to assume that water supply is shut off, but tank heater continues to burn. Relief valve will then be discharging large volumes of steam. Tests shown that capac. of most of simpler valves is not enough to care for steam generated in such case without allowing excessive pressures to build up. For this reason temp. relief valves should be extra large and should not depend on water pressure to operate them, but be actuated solely by temperature.—*Homer Rupard.*

Cross-Connections and the Plumbing Testing Laboratory in the New Bedford Vocational School. E. J. SULLIVAN. J. N. E. W. W. A. **54:** 179 (June '40). Mass. Health Dept. adopted regulations relative to cross-connections on Feb. 9, '37. 16 types of cross-connections listed in article. Methods given for solution cross-connections: (1) approved double check valve installations (new ones not now allowed); (2) indirect funnel connections with 6" air breaks; (3) disconnection of fire pumps from sprinkler systems; (4) approved swing connections and pipes terminating 6" above any tanks; and (5) syphon breakers in certain small cross-connections. Health Dept. surveys indicated many plumbing cross-connections existed which, while not endangering public system (if no cross-connection present), would still endanger users of private system. In latter part of '38, plumbing testing lab. established in vocational school at New Bedford, Mass. Various toilet and plumbing fixtures installed with means for measuring flow, applying and measuring vacuum, visible operation, and for making other tests.—*Martin E. Flentje.*

Plumbing and Public Health. FRED A. PERKINS. Ky. Bul. of Dept. of Health. **12:** 6: 125 ('40). Through application of sanitary measures, yellow fever, typhoid fever, typhus fever, and malaria reduced to small fraction of what they were a generation ago. Plumbing played important role in general

progress of sanitary science. Fact that it takes skilled workman to install good plumbing and that handyman's work jeopardizes health of public demonstrated. Some people do not understand purposes of strict plumbing regulations and do not realize they are designed to protect public health. Ky. General Assembly of '32 enacted plumbing law applicable to counties within state, containing cities of first and second class and all public buildings regardless of location.—*P. H. E. A.*

WATER SUPPLY—GENERAL

Modern Sanitation and Water Supply Practice. Wm. Storrie and A. E. Berry. Eng. Jour. (Canada) **23**: 380 (Sept. '40). Sanitation is major public responsibility which co-operative effort, eng. and research all join to promote. Canadian practice follows U. S. rather than Great Britain. Paper intends to cover only items wherein Canadian practice is peculiar. Activated sludge sewage treatment is predominant because of need for complete treatment, low power costs and high chem. costs. Most parts of Can. have fine sources of water supply. First water supply was constructed in St. Johns, N. B., in 1837. 235 in '00 and 1,258 in '37, serving 54% of pop. Dominion, provincial and municipal govts. all exercise jurisdiction over water supplies. Legislation is comprehensive and reasonably effective. Large pop. centers are on good natural supplies, except where hampered by local pollution. Mountains in west provide good supplies. Low stream flow and recession of underground supplies cause difficulties in northern plains. Rainfall varies from about 10" to 58". Variation of quality of raw water supplies is wide, being determined by source and geological structure of district. Concentration of pop., with few exceptions, has not caused pollution from wastes. Climatic conditions vary widely, with general tendency toward extremes of summer and winter temps. Extended periods of low temp. in northern parts introduce problems of underground water replenishment, resulting in wide variation in surface runoff and causing subsequent bad conditions of supply during periods of low runoff. Early attempts at purification involved use of natural sand formations. About a dozen slow-sand plants have been built. Climatic conditions have caused change to other types. About 47 mechanical pressure filters, first one installed in 1890. Few use pre-treatment. Many cannot handle bad water. One province will not permit installations of this type. Others limit their use. Rapid sand filters, first used in '06, are 68 in no. and are choice wherever efficient treatment is desired. Variation, called "drifting sand filter," has been used. Upper layer of sand is continuously removed, washed and returned to filter. Satisfactory effluents with long runs are obtained. No recent units of this type have been built. Chlorination, with chloride of lime, first used at Toronto in '10, following typhoid fever outbreak. Liquid chlorine, applied in solution to pump suctions, now major means of application. Mechanical equipment subject to breakdowns is avoided as much as possible. Design of intakes important because of prevalence of ice conditions. Inlet screens plug with frazil ice. Intake pipes plug with ice. Ice fields may build up along shore lines and destroy intakes. Bars instead of screens are used. Intakes are placed in deep water, far enough from shore to

avoid other types of trouble. Frazil ice is greatest hazard because low velocities will draw it into intakes. Horizontal approach of water to intakes helps. Intakes must be located so that local pollution does not affect them. Small intakes usually consist of upturned elbow, with a screen, protected by timber crib. Frequently, cover plate is placed over upturned elbow. Good for lakes, but not for rivers because of current. Recent intakes constructed on Great Lakes have inlet velocities of from 4.7" to 32" per sec. Victoria Park intake at Toronto is 10' tunnel, 3,300' long, extending out to 33' of deep water; then an 8' pipe 4,150' long laid in trench in lake bottom to an inlet in 53' of deep water. Pipes were built on shore and towed to site. Inlet circle is 30' in diam., built of steel filled with concrete. Treatment plants generally use 30 to 40 min. mixing, 2 hr. sedimentation, and conventional rapid sand filters. Spiral flow mixers have been favored in recent plants. Toronto is completing 100-m.g.d. plant, with special provisions in filtered water res. for chlorinating and de-chlorinating filtered water. Alum is used for coagulation. Many tanks are designed to produce gentle stirring action without breaking up floc and to prevent short-circuiting. Concrete floor of res. is made water-tight by built-up roofing, topped by 2" of concrete. Tests showed very low leakage from res. Only 3 municipal plants soften water, all by base-exchange method. Liquid chlorine for large plants and hypochlorite feeders for small plants, injected in pump suctions, is general rule. Manual control is generally used. Operators are not licensed. Testing of supplies is provided for, with some variation in practices used in different provinces. All common processes for taste control have been used in various plants. Super-chlorination has been used at Toronto. Pollution at intake has made need for this treatment. Ammoniation, aeration and activated carbon have been used in some plants. Treatment has eliminated water-borne typhoid. All 9 provinces operate labs., some with several branches, for checking quality of public supplies. Availability and low cost of elec. power has caused replacement of much steam pumping equipment by motor-driven pumps. Use of tanks to gain off-peak rates and duplication of power supplies have helped change. Gasoline, diesel or steam engines are maintained as stand-by units in many places. Gravity supplies are rare. Cast-iron pipe and copper services predominate in distribution systems. Some steel cylinder pipes, concrete lined inside and outside have been used recently. Regular snow removal from city streets has caused depths of mains to be increased for protection against freezing. In many cases hydrants are inspected every 2 wk. during winter. Electric thawing machines have come into general use. Average water consumption in 27 cities is 100 g.p.d. per capita, ranging from 40 to 187. Supplies almost entirely publicly owned. Water rates lack uniformity and bear little relation to one another. Administration is by municipal council, public utilities commission, or by special boards or commissions. Legislation for sewerage systems provide for establishment, operation by local unit and for supervision over design and operation by provincial health agencies. 531 sewage treatment plants are in service. Many types have been built, but trend is to sedimentation or activated-sludge type. Treatment requirements depend upon strength of sewerage, stream into which it is dissolved and in many places upon temp. extremes. Sedimentation is used for partial treatment and activated sludge for secondary

treatment. Trickling filters are finding favor for institutional plants. New North Toronto plant is typical of modern trends. Cares for 100,000 people, averaging 7.5 g.p.d. each. In '38, suspended solids averaged 262 p.p.m. and 5-day B.O.D., 255 p.p.m. Plant has grit chambers with a 1′ per sec. velocity, 2 hr. sedimentation with Dorr clarifiers, 5½ hr. retention in aeration tanks when returned sludge is 20% of average flow to plant. Diffuser plate area is 10% of tank area. Final sedimentation is 3 hr., tanks 16′ deep with Fidler type clarifier. Sludge digestion tanks have produced 127,000 cu.ft. per day of gas from a pop. of 82,177. 10 drying beds, glass covered, have effective area of 60,000 sq.ft. Ave. reduction of bacteria was 99.2% and of coliform organisms 99.1%. Climate makes sludge handling problem difficult in many plants. Covered, heated beds necessary. 3 plants de-water sludge. Final disposal is by dumping and as fertilizer. Chlorine has been used on limited scale, chiefly to improve plant operation. Various provinces have different degrees of control over stream pollution. International commission deals with waters which form national boundary between Can. and U. S. Commission has studied problem extensively, finding worst problems in Detroit and Niagara rivers. Stream control in provinces under their dept. of health. Reservoir being built on headwaters of Grand River in Ontario to keep low flow up at higher point. Refuse collection, incineration, swimming pool control, milk control, and general sanitation developing in orderly fashion under proper authorities, to furnish proper protection for public health, with sanitary engr. as guiding spirit, planning for future so that living conditions may be better.—*Homer Rupard.*

British Water Works Practice. JOHN BOWMAN. J. N. E. W. W. A. **53:** 385 (Dec. '39). Due to effects of Gulf Stream, Great Britain has mild climate. Highest Mt. is 4,406′, few others exceed 3,000′. Rainfall for the 121,000 sq. mi. area for wet yr. of '72 was 56.7″, for dry yr. of '87; ave. was 31.8″; normal for England is 32.67″, for Wales 50.14″ and for Scotland 50.32″—in parts of Scotland and Wales rainfall much higher, going up to 200″. Evaporation varies from 11″-17″ per yr., ave. is 14″. Development of systematic water systems not over century old, most companies now municipally owned, but large areas still served by private companies, whose profits are limited by law to 6%. England has 108 towns with pop. of 50,000 or more (total pop. 22.4 million); 26 use river supplies, 27 upland surface sources, 30 underground supplies and 25 mixed sources. Of the 7.3 million pop. supplied by rivers, 6.5 mil. are in London—largest proportion of water then from upland surface sources. These impounded in res. with from 180 to 200 days supply. Practice in G.B. in impounding a supply to provide compensation water for lower users, usually assessed at ⅓ of ave. available yield. Abstraction of underground water by water depts. controlled by law, private individuals not so controlled. Glasgow, second largest city of British Empire draws 90 m.g.d. (U. S. gal.) from Loch Katrine without purification, supply in use over 80 yr. with no cases of waterborne disease. Other large cities, Liverpool; Birmingham, Sheffield, Leeds in Eng. and Edinburgh in Scotland have distant supplies but filter water. Consumption in 6 largest areas in g.p.d. per cap. is: Manchester—49, London—44, Liverpool—42, Leeds—40, Birmingham—37, Sheffield—37. Glasgow uses,

for domestic purposes only, 46 g.p.d. per capita. Considerable confusion exists in standardization of pipe fittings. Cast iron and steel pipe used now, with asbestos-cement to considerable extent; lead always used for service, lead and copper in houses. Main pipes in most towns inadequate for fire-extinguishing purposes. *Discussion.* As a matter for comparison, normal annual rainfall of northern New Eng. is 38.81", for southern, 44.26"; in central Conn. for years of record 1868—'38 inclusive, 28.90" or more annual rainfall fell in all years, 38.95" or more, 75% of time, 43.40" or more, 50%, 48.36" or more, 25%, and 56.95" or more 0%. In Mass. out of 282 supplies 140 are from ground water, 142 from surface sources; in Conn. of total of 116, 67 are surface supplies, 39 groundwater and 10 combined. For 25 largest cities, res. storage averages 316 days supply, of these only 7 under 100 days.—*Martin E. Flentje.*

Metropolitan Water Board. 33rd Annual Report on the Results of the Bacteriological, Chemical, and Biological Examination of the London Water for the Twelve Months Ended 31st December, 1938. E. F. W. MACKENZIE. P. S. King and Son, Ltd., London. 118 pp. Average daily output—317.61 mil. gal.—of water from works of Metropolitan Water Board in '38 represents daily increase of nearly 7 mil. gal. over amt. supplied in '37. 98.5% of all samples showed no coliform organisms in 100 ml. Two modifications introduced in routine test for coliform organisms: (1) substitution of brilliant green bile broth for indole test as a rapid confirmation of presumptive coliform test, and (2) use of citrate medium as one of confirmatory tests. Comparative tests over period of 10 mo. showed that brilliant green medium gave larger percentage of positives than MacConkey broth, but that differences were mainly due to large discrepancies in months of Oct., Nov. and Dec. Reason for this is being investigated. Citrate test was modified by addition of brom-thymol blue, which indicates growth of bacteria by change from apple-green to blue. Was found that, for direct inoculation into MacConkey broth, an incubation temp. of 42°C. was preferable to one of 44°C., since higher percentage of positives was secured at lower temp. On other hand, comparative tests indicated that test at 44°C. may be, in part, specific for *B. coli*, Type I. It may thus be possible, in confirmation of presumptive positive tests, to replace plating and differential tests on isolated colonies by much simpler process of subculturing in MacConkey broth and incubating at 44°C. for 24 hr. Tests for *Clostridium Welchii* with Wilson and Blair's medium showed that 44°C. was as satisfactory as 45°C. for incubation of plates and that appearance of black colonies 3 mm. or more in diam. is highly significant. Use of potassium tellurite for isolating streptococci has considerably modified interpretation of this aspect of water bacteriology and fresh investigations are being made to assess importance of group as indication of faecal pollution in water. Investigation is being made into importance of soil bacteria in bacteriology of water. Nitrate-reducing bacteria were found to be numerous, amounting to more than 50% of total flora of water in summer and 10.25% in winter; they consisted of coli aerogenes types, *Ps, fluorescens*, Actinomyces, and unidentified chromogenic organisms. *Nitrosomonas* and *Nitrobacter* were comparatively infrequent in water samples. Complaints of earthy tastes in drinking water led to preliminary investigation which showed that no. of Fungi Imperfecti and Actinomyces are capable of

producing such tastes. Former appear to be more important in practice and may find suitable conditions for establishing growth in comparatively warm and semi-stagnant water in cold-water pipes of some centrally-heated buildings. In addition to routine chem. exam. of samples of raw, stored, filtered, and well waters, tests were made for electrical conductivity, free carbon dioxide, and dissolved oxygen in well waters, and turbidity of filtered waters; many other tests were made for constituents which have commercial rather than sanitary significance. Special analyses are also being made with view to elucidating chem. problems connected with growth and control of algae in reservoirs. Most important of these are estimations of phosphates, silicates, and nitrogen. Forecasting duration of algal growths in reservoirs is part of work of biological section and, though this phase of study is still in its infancy, such success as has already been obtained dates from introduction of routine exam. of dissolved phosphorus and silica. Concentrations of these two substances are apparently inversely correlated with abundance of diatoms. Detailed study along these lines, of standing reservoir at Barn Elms, has suggested fresh line of approach; namely, role of bacteria in bringing about decomposition of algae on floor of reservoir. An account is given of appearance in another standing reservoir of "blue-green" alga, *Oscillatoria rubescens*, and of chem. conditions prevailing. As existing method of estimating algal abundance, which depends upon measuring filterability of water, though of value to eng. staff responsible for filtration, is not sufficiently accurate for more difficult task of forecasting duration of algal growth, 3 new methods are being incorporated in routine biological work of '39. These involve making of photo-micrographs and counts on algae after concentration, enumeration of algae per unit vol. of water, and modified method of extraction and estimation of chlorophyll. Study has begun of flora growing on sand surface of some 119 secondary and slow sand filters. Report includes subject index to previous annual reports and research reports.—*W. P. R.*

A Rural Water Supply Scheme in Dumfriesshire. Falconer Keir. Wtr. & Wtr. Eng. (Br.) **42:** 248, 274 (July, Aug. '40). Total area of Dumfriesshire 1,091. sq. mi., about $\frac{1}{3}$ agric. land, remainder mountain or hill pasture, waste or woodland. First problem was to determine what quantity of water per capita (pop., 15,885) should be considered sufficient. Actual amount of water used on a farm is out of all proportion to its domestic needs. With allowance of 60 gal. (Imp.) per day, total quantity of water required is about 1 m.g.d. (Imp.). Suitable site for dam having been selected it was decided to impound 180 mil. gal. (Imp.). Storage provides for dry-weather period of 185 days. Aqueduct consists of a open concrete channel 2,200′ long. During construction of Kettleton dam, stream was diverted through reinforced concrete culvert which passes through puddle core of dam. On upstream side dam has slope of 3:1 as far as top water level, and thereafter 1.5:1 to crest. Downstream side has ave. slope of 2.5:1 with two 10′ wide berms. Spillway channel is of reinforced concrete. Dam is 67′ high at its max. width, and it is 410′ long at crest. Water passes from res. through a 14″ diam. steel pipe to filters and clear water tank, which has a capac. of 250,000 gal. (Imp.). Two batteries of pressure filters, each with 4 units with a total capac. of 1.06 m.g.d.

(Imp.). Primary distribution system leads to 6 service tanks. Secondary system covers remaining area within districts. At points where not practical to install break-pressure tanks, pressure-reducing valves have been inserted. Working pressure on main at Kirkton branch take-off is 225 lb. per sq.in. First 20 mi. of main pipe line is steel. Pipes are 14", 12", and 10" nominal bore, in two classes capable of standing 750' and 1,100' of head. 294.61 mi. of asbestos-cement pipe has been laid, with sizes varying from 7" to 1½" diam. There were in existence a no. of small water districts which had to be linked up with new distr. system. In Lower Annandale District, Winterhopehead Res. has been constructed with capac. of 80 mil. gal. (Imp.), improvements to existing distr. system were approved, and an additional filter has been allowed for at Torbeckhill Res. Extent of distr. system in combined districts is 672 mi. of pipes, most comprehensive rural water supply in Scotland.—*H. E. Babbitt.*

Water Supply Research. ANON. The Engr. (Br.) **169:** 326 (Apr. 5, '40). Department of Scientific and Industrial Research has opened new water pollution research lab. at Watford, equipped for work on problems of water supply, sanitation, and recovery and utilization of valuable materials from trade effluents of many kinds. Has been shown, for example, that by treatment of certain clays and glauconitic sands found in England, materials can be obtained which are equal to minerals now imported from abroad for use in softening hard water.—*H. E. Babbitt.*

Water Supply and Sanitary Engineering in 1939. ANON. The Engr. (Br.) **169:** 91 (Jan. 26, '40) *Belfast*: 32 sq. mi. added to district of supply requiring extension of distribution system. Construction work included a filter house; a 3 mil. gal. (Imp.) low-service res.; a 600,000 gal. (Imp.) high-service res., with appurtenances; a rapid filter plant and sterilization apparatus for 1 m.g.d. (Imp.); 8 mi. of distribution mains between 15" and 4"; and other minor work and equipment. *Birmingham*: 60 mi. of supply mains; a 60" concrete-lined steel main on Elan Aqueduct; 3¾ mi. of 36" concrete-lined steel main from Highters Heath Res.; and 2 mi. of 15" c.i. pipe in district of Solihull. Also constructed an 18 mil. gal. (Imp.) concrete, service res. Steam pumping plant at Edgbaston replaced by electrically driven pumps. 24" steel-lined concrete main and a 15" c.i. main laid in connection with air raid precautions work. *Corby*: Construction of Eye Brook Res. continued, and works are approaching completion. Impounding in res. commenced in Dec. *Edinburgh*: Most of work for year in connection with air raid precautions. Included laying of additional mains and installation of over 100 valves on leading mains. *Glasgow*: 2½ mil. gal. (Imp.) reinforced-concrete service res. to augment storage capac. in vicinity of Springburn Park. *Liverpool*: 3 mil. gal. (Imp.) reinforced-concrete service res. constructed to meet demands of Speke and Garston districts. Work commenced on about 7 mi. of 42" bitumen lined steel pipe, branching into two 30" steel tubes. Work is 33% complete. *Manchester*: 6 Peebles rotary strainers, with capac. of 10 m.g.d. (Imp.) through 100-mesh wire cloth were installed at Horwich. New electrically-driven booster station, with capac. of 10,000 gal./hr. (Imp.) was installed to increase pressure in

North Cheshire area. Chloramine plants installed at outlets of 4 largest service res. *Rugby*: Contracts for both Northern and Southern Area water supply schemes were let, involving about 44 mi. of pipes at estimated cost of £44,000. *Rangoon* (*Burma*): Embankment on 14,800 mil. gal. (Imp.) Gyobyu Res. is about 85% complete. About 60% of 43-mile, 56″ concrete-lined steel pipe to Kokine Res. has been completed.—*H. E. Babbitt.*

Presidential Address, Health Congress at Scarborough, (Eng.). W. J. E. Hinnie. Jour. Royal San. Inst. (Br.) **60:** 139 (Oct. '39). About 95% of pop. of Eng. and Wales now provided with public water supply, within recent years assistance given to local organizations to provide public water to rural districts. Usual practice in impounding res. design to provide a res. of such capac. as to insure a supply equal to the ave. flow of a stream during 3 driest years. Has been ascertained that ave. rainfall during 3 driest consecutive years is approx. $\frac{4}{5}$ of the ave. annual rainfall. Loss by evaporation, absorption, etc. from res. may be as much as 12″ in Highlands of Scotland to 22″ in south-west of Eng. 15 days storage in res. will reduce total number of bacteria to about $\frac{1}{20}$ of original no. Dangerous bacteria are not, however, ever completely eliminated. Rapid sand filters if open, usually have air and water wash; used both as primary and final filters.—*Martin E. Flentje.*

Water Supply Undertakings in the United Provinces, India. *Annual Report of the Superintending Engineer, Public Health Engineering Department.* Wtr. and Wtr. Eng. (Br.) **42:** 198 (May, '40). Duties of the P. H. Eng. Dept. include supervision and inspection of all open water works, drainage pumping stations, and hydro-electric supplies; in addition, advice and recommendations are given to several govt. depts. and, free, to local authorities on matters within the scope of p.h. eng. Now are 25 water undertakings in Provinces, with a total urban population of 1,654,073 served, with an ave. daily supply of 45,486 mil. gal. (Imp.). Highest cost per thousand gal. (Imp.) was 26.77 annas, lowest, 0.81 annas. Some boards ran their works at a profit. In some works, although consumption is increasing, regular decrease in income is noticeable. Although waste prevention measures have been started, progress made has not been commensurate with expenditures incurred. Shortage of water in outlying districts of all large towns still persists.—*H. E. Babbitt.*

The Problem of Water in Algiers. Anon. L'Eau. (Fr.) **32:** 66 (Jun. '39). (From Les Travaux Nord-Africains.) Pop. of Algiers has greatly increased since 1870 and various attempts have been made to increase water supply, but with total failure or only partial success. Distribution system is 100 yr. old, was built without an integral plan and is unsatisfactory, especially in certain parts of city. Estimated that reconstruction of distribution system and increase in water supply to meet present needs for domestic and industrial consumption and fire protection would cost over 50,000,000 fr., an amt. apparently impossible for the city to obtain from public sources. Recently private concessionaires have made offers to install new water system and offer made by the Lyons Water Society has been accepted, thus assuring water supply development by private organization which city itself found impossible to

carry out. **Erratum.** L'Eau. (Fr.) **32:** 84 (Jul. '39). Solution outlined by Mayor of Algiers has not been approved by Council, and study is now under way to determine best methods available.—*Selma Gottlieb.*

Fifty Years of Water Supply in Leipzig. B. BFEIFFER. Gas- u. Wasser. **81:** 371 ('38). Brief historical description of development of water supply and works of Leipzig since 1887. 2 water works were constructed at Naunhof in 1887 and in 1895, obtaining a supply of ground water from a depth of 10-18 m. Third works, at Canitz, was built in '12. In addition there are 7 small works yielding in all about 10% total supply. Whole of supply is derived from underground sources. Developments since installation of these works have been replacement of steam pumps by electrical pumps, addition of a plant for removing manganese from water at Canitz works, installation in '30, at all three works, of plant for de-acidifying water by addition of milk of lime, and, in '32, construction of an establishment to test metering devices to reduce loss of water in distribution system. Iron is removed from raw water at Naunof works by allowing water to flow freely through an underground canal to sand filters; this causes flocculation of iron which is easily removed by filtration. Difficulties experienced in filtering off the iron after installation of the de-acidification plant, were remedied by using finer sand in filters and by washing filters more frequently at carefully controlled rates. Wash water is settled to remove iron sludge. Clear water is refiltered and goes into supply; sludge is discharged to sewers. (See also abstract Jour. A. W. W. A. **28:** 822 (Jun. '36)).—*W. P. R.*

Water-Supply and Drainage Conditions in the Country. Some Technical Problems Concerning Sweden. A. MOLIN. League of Nations Health Organization Rept. (Geneva), ('38). Brief account of facilities for water supply and disposal of waste waters in country districts in Sweden. Both ground and surface waters are used as sources of supply. Gravel wells are usually 10-15 m. deep. Electrically driven pumps are frequently employed to obtain water from wells since electric power is available even in country districts. In many places in Sweden a continuous lowering of ground water level has been observed; this has necessitated replacement of pumps erected at ground level by new type of submerged pump fixed in the casing of well. Wells in sand beds are 2-5 m. deep and are constructed of reinforced concrete. Wells bored in rock are usually about 60 m. deep; from a well 100 m. in diam. 66-220 gal. of water can be obtained per hr. In some places it is necessary to augment supply of ground water by taking water from lake or stream; surface water nearly always requires purification. On some estates ground water is supplied for domestic purposes and surface water for washing, etc. Towns in Sweden are usually well provided with suitably treated drinking water but country estates and isolated dwellings as a rule possess no means of purifying their water supply. In latter case, expert advice should be sought as to most effective means of treating water; many types of apparatus are available. There are facilities for disposal and treatment of waste waters in towns in Sweden but in country districts difficulties are frequently encountered, especially where there is no available dilution for wastes. Emscher tanks are employed

in some villages with 100-200 inhabitants. Special drainage tanks, which allow deposition of slime without passing waste water through slime-collecting chamber, are available; these tanks are not effective if overloaded. In some places effluent from settling tank is allowed to percolate into ground. This method of disposal should only be practiced where there can be no danger of pollution of sources of water supply.—*W. P. R.*

The Chilcote Pumping Station and Softening Plant of the South Staffordshire Water Works Company. ANON. Engineering (Br.) **149:** 451, 495 (May 3, 17, '40). Total no. of main pumping stations forming company's main source of supply is now 22. To obtain definite information regarding ultimate effect of pumping operations after construction of Chilcote Pumping Station, 8 tube wells, lined with 2" internal diam. steel tubes, were driven around site. Excessive chloride content was found in bottom water where sulfate content was also very high. Was, therefore, decided to cut off lower part of well. Lime and sulfate constituents were much reduced, while magnesia remained unaltered. Main wells differ in design and construction. No. 1 is 44" internal diam. at top and varying down to 21" at bottom depth of 695'. In yield test on No. 1, quantity was gradually increased to 60,000 gal. (Imp.) per hr., at which rate it remained constant throughout test. Pumping plant includes duplicate electrically-driven centrifugal pumps and duplicate power supply. Lift of 50' above floor level of well pumps enables water to be pumped to softening plant. Pumping station building is constructed chiefly of brickwork, faced with "Rustic" bricks with white stone base and dressings. Filtration and chemical bldgs. are designed in keeping with engine house previously erected. At east end of filter house are lab., workshop, heating chamber, CO_2 house, and coke store. During early stages of life of plant, volume of water to be softened is 1.5 m.g.d. (Imp.), with possible increase to 2 m.g.d. (Imp.). Raw water from main pumps rises in access house adjacent to deposition tank. Lime cream is delivered into raw water as it enters launder, and coagulants are applied at suitable points in launder or mixing chamber. Flocculated water rises in center of deposition tank, ultimately finding its way to 2 circumferential channels. Capac. of deposition tank is 400,000 gal. (Imp.) with internal diam. of 45'. Lime used contains 90 to 95% CaO, and is handled mechanically. In operation, lime continues to be fed into one or other of slakers until required total weight is shown by indicator on weighing machine. While slaking is going on, basket is revolved and when batch has been slaked completely it is run to storage tanks. Portion of cream of lime is kept in continuous circulation, thus avoiding deposition in measuring apparatus. 2 dry-feed machines can be used for either sodium aluminate or sulfate of alumina. Portion of water is treated with carbon dioxide, generated in two stoves fed with metallurgical coke. Relatively small quantity of water containing CO_2 is injected into whole volume of water which is delivered into annular tank from deposition tank. 12 filters are provided for dealing with 1.5 m.g.d. (Imp.). Filters are back-washed with air and water. Each filter is fitted with a clarity indicator so that attendant will know when washing operation is completed. Dirty wash water is taken to waste-water recovery tank. All waste water is allowed to stand until bulk of precipitate has settled out. Supernatant liquid is then passed again through filters.—*H. E. Babbitt.*

Water Supply of Rangoon, Burma. ANON. Engr. (Br.) **169:** 488, 508 ('40). Pegu Yomas scheme, involving construction of dam across valley in Pegu Yomas hills to form Gyobyu res., has been undertaken to augment water supplies of Rangoon, Burma. At present supply is at most 12.7 m.g.d. (Imp.), sufficient to meet needs of about 310,000 of total pop. of 400,000. Gyobyu res. has catchment area of 12.9 sq. mi.; 90% of total annual rainfall of area (110 in.) falls in monsoon season. New res. will have gross capacity of about 17,000 mil. gal. (Imp.), of which about 8,500 mil. gal. (Imp.) will be available for supply to Rangoon. Construction of dam, overflow weir and channel, and tunnel through which water was diverted during construction of main dam, described. Water conveyed to Kokine service res. at Rangoon in steel pipe line 43.5 mi. long, at elevation just above tidal level. Pipes are lined internally with fine portland cement concrete, 1″ thick, to prevent corrosion, to give rigidity, and to reduce heating of water by sun. Construction and laying of pipe line described. Water supplying res. very turbid; coagulating basin is situated about 1,500 yd. below valve shaft at Gyobyu dam. Coagulants are added and floc is removed by screening. Water is treated with ammonia and chlorine before entering supply system.—*W. P. R.*

Rand Water Board (South Africa), 35th Annual Report. (Year ending Mar. 31, '40). Water supplied Johannesburg (pop. 537,217) and 9 additional communities and "farms" with total pop. of 1,139,854. Increase in demand for water continued (*see* abstract, Jour. A. W. W. A. **31:** 2180 ('39)). Ave. m.g.d. increase '40 over '39 equalled 4.82; ave. daily for yr. being 46.40 m.g.d. with max. 24-hr. consumption of 59.44 m.g.d., min. of 35.33 m.g.d. Additional water supply completed during yr. increased capacity by 20 m.g.d., up to 68 m.g.d., total now available. Rainfall for yr. was 35.25″ compared to 35.08″ in '38, and 32.80″, 51 yr. ave. Water, as in previous years, treated with alum, lime and chlorine. Report illustrated with numerous charts and tables.—*Martin E. Flentje.*

The Water Supply of Bucharest. LOUIS STANISAVLIEVICI. Gas u. Wasser. **83:** 55 (Feb. 3, '40). Originally private and public wells were used and also river water directly. From 1882–89 filtration plant was built at Arcuda about 12 mi. upstream of Bucharest on river Dimbowitza. Consisted of 4 sedimentation basins of 72 hr. retention period and 2 filters each 3,300′ by 33′. Although plant was built for 10 m.g.d., it could never produce over 7 to 8 m.g.d. In '13, improvements were made mainly by subdividing long filters into 3 parts each. Increased demands forced construction of additional supplies—in '02 a ground water plant at Bragadiru, 10 mi. from capital, for 15 m.g.d., having 280 wells; and in '05, a ground water work at Ulmi, 16 mi. to west for 12 m.g.d., having 230 wells. In '27, plant at Arcuda was improved by building pre-filters of Puech-Chabal type. Projected now is additional surface supply from river Arge for 50 m.g.d. As auxiliary supply, important in case of war, several deep wells, in city, which furnish an alkaline but soft water can be used. Otherwise city water is fairly hard (ave. 170 p.p.m.). Cast-iron distribution system is about 400 mi. long. All house connections are metered. —*Max Suter.*

The Provision of Potable Water Supplies in the Netherlands. W. F. J. M. KRUL. League of Nations Health Organization Housing Com. Rept. (Geneva), ('38). Outline of development of water supplies in municipal and rural districts in Netherlands, including descriptions of legislation relating to water supply, work of State Bur. for Water Supply (Rijksbureau voor Drinkwatervoorziening) and of Central Com. for Water Supply (Centrale Commissie voor Drinkwatervoorziening), and decrease in death rates since provision of potable water supplies. A program of studies to ensure provision of future supplies is described. It includes plans for study of resources of country, estimation of future requirements, and investigation of methods for purification of water and for prevention of pollution. Each of 70 towns in Neth. has a piped water supply and 85.7% of rural population are connected to municipal, local or regional supply systems. Largest regional supply, serving province of Northern Holland, supplies 106 communes, with total pop. of over 430,000; over 14 mil. cu.m. of water are supplied annually. Map is included, showing distribution of local and regional water supply systems in Neth.—*W. P. R.*

***United States* v. *Appalachian Electric Power Co.* in United States Circuit Court of Appeals, Fourth Circuit.** Pub. Util. Fort. (Jan. 18, '40) P.U.R. **31**: 65. Review of District Court decisions granting company right to build dam, waters of stream not navigable. Title to beds of navigable waters vested in state, unless state laws grant them to riparian owners. Right of U. S. is limited to control of navigable waters, no property rights. Control of intrastate streams remains with state whether navigable or not. Federal legislation only permissible when relating to control of navigation. Rivers and Harbors Act provides unlawful to erect any structure, on, over or in navigable waters without consent of Congress, Chief of Engineers and Secretary of War. On interstate strip, navigable only when used or susceptible to use in natural condition, each case must be decided separately. Erection of large dam with locks by Federal Govt. approved by War Dept. important evidentary facts upon navigability of waters. Burden of proof on Federal Govt. in case of erection of dam. A river not navigable in natural condition, is not considered navigable if works are proposed, but not made. If work was experimental, executed and abandoned, it does not prove river navigable. Government has burden of proof to show that dam on upper part of stream or tributary, would affect navigation below. Supreme Court has decided that it always is a question of fact, whether appropriation of upper waters of stream interferes within limits where navigation is a fact. No proper waiver of constitutional rights results from application to Federal Power Com., to find commission is without jurisdiction. Federal Power Act of '20 intended to assert control, where Federal property is not concerned, only where the interests of navigation as an incident of interstate commerce are affected. Congressional jurisdiction over non-navigable waters, only with respect to protection of navigation of other streams. Riparian owner on non-navigable stream entitled to reasonable use of flowing waters, not impairing downstream navigable capacity, right cannot be taken from him without just compensation. Congress has no authority to take private property without just compensation

as an exercise of regulation of commerce. Court of Appeals affirms, one justice dissents.—*Samuel A. Evans.*

Re: Scott Water Plant. **Montana Board of Railroad Commissioners.** Order of Commission. Pub. Util. Fort. (Jan. 18, '40) P.U.R. **31**: 124. Investigation of water rates and service: rates reduced and improvement of facilities ordered. Rate of return 10.36% on valuation of property, termed excessive. Commission engineer testified property, including pipes and mains in good condition, allowance of 3.78% of value of depreciable property, utility allowed return of 6% upon present value of its property. Utility obligated to render good and reasonable service for rates charged, service in this case inadequate utility ordered to construct tank.—*Samuel A. Evans.*

HYDROLOGY

The Unit Hydrograph Principle Applied to Small Watersheds. *Discussion of previous paper.* Proc. A. S. C. E. **66**: 150 (Jan. '40) FRANKLIN P. SNYDER: It is possible that for short period of time ground water discharge may actually decrease at greater rate following occurrence of runoff than before. Results from large drainage basins show that period of rise of unit hydrograph is independent of duration of rainfall so long as period does not exceed period of rise. Usually period at beginning of rainfall during which no runoff occurs, and rainfall in this interval often referred to as initial loss. Time used with unit hydrograph has appreciable effect on results. Unit should be considerably less than period of rise. *Ibid.* **66**: 1070 (June '40) *Author's Closure*: Analysis was based on study of 22 small southern Appalachian watersheds. Results reflect influence of topography, soil, and vegetation of this region. Must be recognized, therefore, that some of conclusions may have to be modified if they are to be applied to other localities. Main purpose of paper was to study application of unit hydrograph to small watersheds. Seemed desirable to keep discussion, as far as possible, in terms of well-known and accurately definable quantities. For this reason, runoff coefficients were used instead of newer conception of infiltration capacity.—*H. E. Babbitt.*

Present Knowledge of Temperature Relations of Small Bodies of Water. W. PICHLER. Int. Rev. Hydrobiol. **38**: 231 ('39). Describes study of temp. in small pools, stagnant or uninfluenced by inflowing water, which exhibit homothermy, or uniformity of temp. from surface to bottom, for at least some part of day, and whose daily changes in temp. are comparable with yearly variation of larger lake. Author classifies small, completely stagnant, bodies of water into three types: (1) puddles, less than 0.2 m. deep with practically no temp. stratification, and daily temp. variation of up to 25°C. in summer; (2) pools, up to 0.6 m. deep with temp. stratification daily interrupted by period of uniform temp. and daily variations in summer of up to 15°C. in surface water, and up to 5°C. in bottom layers; and (3) ponds, over 1 m. deep, with temp. stratification interrupted by daily period of homothermy which occurs in deeper ponds only after several days of bad weather, and a daily temp. variation in summer of up to 10°C. in surface water and up to 2°C. in

water at bottom. Meteorological factors such as wind and cloud have considerable influence, as also has content of suspended solids in water, which causes slower penetration and longer retention of radiation; clear mountain waters, on other hand, are subject to frequent fluctuations in temp.—*W. P. R.*

Measurement of the Rate of Exchange of Oxygen Between a Water Basin and the Atmosphere. G. Vinberg. Compt. Rend. Acad. Sci. (U.S.S.R.) **26:** 666 ('40). On basis of theoretical considerations and equations, following method for detn. of exchange of O between atm. and a lake was worked out. O content was detd. every hr. from 8 P.M. to 3 or 4 A.M. at depth of 1.2 m. and on water surface in a tin tank immersed in lake. Object of latter was to det. effect of mixing with underlying layers lacking O. When relatively stable temp. prevented considerable blending of various layers, changes in O content in waters of lake and tank were practically identical, so that observations on O content of water in tank could be used for calcns. Amt. of O exchanged with atm. per sq. m. within 24 hr. is detd. by the ave. diurnal percentage of O satn. of surface layers of water. In Black Lake of Kossino percentage was nearly 140. Thus through 1 sq. m. of lake's surface, in July, 1938, about 25 grams of O_2 passed into the atm. 10 refs.—*C. A.*

Dewponds in Fable and Fact. A. J. Pugsley. Country Life Ltd., London, '39. 72 pp. Book gives results of observations of a large number of ponds and summarizes conclusions of other writers and correspondents. Beginning with account of legends which have surrounded mystery of dewponds, author proceeds to review authoritative publications on subject. Chapter on "Where the ponds are found and how they are made" and another on "Some theories of their action." Only about a quarter of reputed dewponds examined showed anything curious about maintenance of water level; rest were aided by surface drainage in some way. Unassisted ponds are not really dewponds but well-made rain catches with good collecting margins; many of them dry up in times of drought, only larger ones surviving. Though ponds are ceasing to be of great value to agricultural community, there are still areas where they can be profitably employed. In absence of clay pocket and where expense can be borne, concrete ponds with expansion joints on firm foundations will be best in long run. Natural run of surface water in heavy rain should be studied and pond should be placed to make most of it. Road drainage should not be allowed to enter, as oil scum from it may prevent purifying action of bacteria and oxygenating effect of plant life. Although evidence points to rainfall as essential factor in their maintenance, problem of dewponds will never properly be solved until more independent information about rainfall and periodic change in depth of ponds is obtained by people accustomed to take continued reliable scientific observations.—*W. P. R.*

Effect of Flooded Soils on the Hydrochemistry of Reservoirs. S. M. Drachev, T. K. Karel'skaya and E. S. Bruk. Bull. Soc. Naturalistes Moscow, Sect. Biol. **48:** 4: 51 ('39). Swampy soils, such as peat bogs, have greatest effect on taste, odor and color of water. Alluvial sub-soil has least effect, and removal of top soil before flooding reduces possibility of persistent undesir-

able taste and odor to a min. Interaction of water and soil after flooding starts a series of physicochem. and biol. processes. When access of O is limited and large amts. of org. matter are present, reduction sets in; this causes transition into sol. form of considerable amts. of Mn, Fe, N, P and org. compds. Rate of biochem. O consumption of soils varies according to type of soil, moisture content and fertility.—*C. A.*

Transient Flood Peaks. *Discussion of previous paper.* Proc. A. S. C. E. **66**: 995 (May '40). KARL J. BERMEL: Attention should be drawn to fact that runoff, containing debris from given area, cannot be expressed as a percentage of rainfall on that area unless quantity of transported material is negligible. Major factors that contribute to error of using rainfall, as measured by a standard U. S. Weather Bureau rain gage, as a measure of watershed interception, excluding factors of number and location of gages, are inclination of rain, gradient of watershed slopes, and aspect of these slopes with respect to rain inclination. In predicting runoff rates, or in assigning various coefficients to runoff, it is necessary first to be able to ascertain amount of rainfall intercepted by watershed. R. W. DAVENPORT: Generally, in all except largest rivers, floods peaks have characteristic of being comparatively brief and transitory and of occurring in many streams almost simultaneously. Complex problems related to determination of peak discharges is particularly challenging in floods of so-called "cloudburst" type. If surge-like flood of water, unmixed with debris, were passing down a channel that previously was essentially empty, magnitude of surge would tend to diminish progressively because of steady depletion by channel storage. If similar flood were collecting in channel system and passing down main channel as rapidly increasing discharge, and if in the forepart of flood a large quantity of mud, gravel, boulders and all kinds of trash were introduced, effect on flow would be pronounced. Actual discharge represented by such a moving dam with its following pond of water and debris would seem to depend not only on rate of movement of dam and rate of flow of oncoming water, but also upon what portion of such oncoming water goes temporarily into channel storage behind moving dam. Approaches to problem on broad basis of available knowledge of rainfall rates, etc. may contribute materially to an understanding of flow characteristics of transient flood peaks. *Ibid.* **66**: 1104 (June '40). WALTER J. WOOD AND MAXWELL BURKE. Although rainfall conditions described by author may produce cross-sectional areas of flood measured by him, wave formation may occur even if it is unaccompanied by sudden rainfall increase. Formation of waves, termed "travelling waves" or "slug flow," can increase cross-sectional flow area to many times that occupied by average flow. This type of surge flow or "travelling wave" flow has been observed in Los Angeles County under practically every condition—with and without included debris, in natural channels and in artificial channels. The district has in operation at present time a total of 16 debris basins in the Montrose and other areas. They have proved their value in areas where burns have occurred and where debris flows above highly developed residential areas. *Ibid.* **66**: 1337 (Sept. '40). *Author's Closure.* Combination of circumstances which produced "New Year's Day Flood" of '34 is of such rare occurrence that repetition in

same general region is almost outside range of reasonable probability. Can be stated as almost axiomatic that no floods will develop from mountain watersheds of Southern Calif. until rainfall of heavy intensity, extending over several hr., occurs subsequent to aggregate rainfall exceeding 10" within previous two weeks and has saturated the watershed. Other aspects of situation, either involving debris in rapid movements along channel, or debris which is being lifted gradually about in channel, offer alternative bases for interpreting phenomena described, and point out new directions for observation and study. —*H. E. Babbitt.*

Record Rains Flood South Central Louisiana. ANON. Eng. News-Rec. **125:** 200 (Aug. 15, '40). Record-breaking rains during 96-hr. period, ending Aug. 10, flooded area about 70 mi. long and up to 50 mi. wide, necessitating evacuation of 10,000–15,000 people. At Abbeville, rainfall was 31.66" in 4 days, including 17.5" in 24 hr., which is close to state record rainfall for one month—36.91", established at Alexandria in 1886. At Lafayette, 96-hr. total was 26.95", including 19.63" in 24 hr. This is new record for 24-hr. rain for southern Louisiana, old record being 18.5" at Pharr in '27. All-state record for 24 hr. is 21.4", at Alexandria in 1886.—*R. E. Thompson.*

Drought in Sweden. R. S. Teknisk Tidskrift, Uppl. E. (Sweden) **70:** 56 (Apr. '40). Favored by nature with superabundant waterpower, Sweden has become increasingly dependent upon electricity for heat as well as for light, thereby releasing a corresponding proportion of her forest resources for more valuable purposes. Earliest indications of present water shortage followed the subsiding of spring freshets in '38, when, already, war, which also cuts off most of Sweden's coal supply, was felt to be impending. Legislation to cope with water shortage was unfortunately deferred until Aug., '39, when spring and summer freshets had passed; moreover, phraseology adopted had result of restricting ameliorative effort to about 25% of existing water power, because limitation of volume of discharge was made principal aim. Measures to maintain and raise water levels would have been more efficacious. Good beginning has, however, been made; list is given of 25 sizeable lakes, with combined area of 2,266 sq. km., which are now under control. It is felt, judging from '14–'18, that so long as war lasts, difficulties cannot be altogether eliminated, at worst that is, for five years, according to the govt.—*Frank Hannan.*

Permissible Composition and Concentration of Irrigation Water. *Discussion of previous paper.* Proc. A. S. C. E. **66:** 1368 (Sept. '40). CARL R. SCOFIELD: Engrs. would like to have rule to establish composition of irrigation water. Almost universally true that soil solution is more concentrated than irrigation water by which it is replenished. Both evaporation and plant absorption tend to concentrate soil solution. Criterion as to upper permissible limit must be matter of definition. No definite list of permissible concentrations has been given because: (1) no relation between concentration and composition of irrigation water and that of soil solution; (2) crop plants differ widely in reactions to same salt constituent; and (3) climatic conditions in-

fluence plant reactions to salt constituents. WALTER W. WEIR: Kelley has very carefully avoided statement of how much salt may be contained in irrigation water and still leave it suitable for irrigation purposes. Has shown clearly that poor drainage is likely to be more important factor than salt content of irrigation supply. ROBERT S. STOCKTON: Long continued use of water for irrigation on certain lands has tendency to load soil with salts deleterious to plant growth. Slow filling of soil with salts was probable cause of abandonment of ancient irrigation systems. Since changes usually occur slowly, chance to distribute capital loss over a period of years. Probability of concentration of alkaline salts in soils under irrigation justifies much greater expenditure for deep drainage than was formerly thought necessary. Engrs. should never lose sight of losses in soil fertility due to irrigation that puts water below root zone; and further, that if soils are kept rich in nitrogen and humus, very much less water is necessary to be supplied by irrigation, and evil effects are minimized.—*H. E. Babbitt.*

Boron Creates Special Problems in Los Angeles Water Supply. ANON. Eng. News-Rec. **125**: 113 (July 18, '40). Extensive investigations conducted since discovered some 10 yr. ago that boron in irrigation water was responsible for leaves of citrus trees, in certain Los Angeles orchards, turning yellow and dropping off, and crops being greatly reduced. Two outstanding facts established: (1) crops under consideration require some boron, and (2) some crops, particularly citrus, avocado and tropical trees, are injured by too much boron. Upper and lower limits and range between permissible limits differ widely for different plants. For example, sultana grapes show deficient growth and crop production when boron content of water is 0.05 p.p.m., grow best with 1 p.p.m. and are severely injured by 5 p.p.m. Date palms show deficient growth with 5 p.p.m. or less and will tolerate up to 100 p.p.m. Min. for citrus fruits is unknown but injury occurs at 0.75 p.p.m. Sulfate appears to be detrimental in presence of boron, but it is uncertain which is active agent and which catalyst. Concluded that if boron was kept below 0.75 p.p.m., water would be safe for citrus irrigation. Quality for drinking water not in question, as boron content may be as high as 30 p.p.m. without quality impairment. Studies of boron sources in Owens Valley showed that 75% of boron content of aqueduct water came from Hot Lake area, 15% from Hot Creek and 10% from all other sources combined. Boron concentration increased at points where hot gases and hot water containing boron bubbled up through lakes and springs. By arranging periodical shutdowns of aqueduct for repairs to coincide with peak boron runoff, as much as 300 tons of boron per yr. has been kept out of aqueduct. Spreading water over land formerly irrigated but now abandoned and pumping from wells downstream removes practically all boron. Completion of Long Valley Dam will prevent latter practice. New program will be to convey aqueduct water through danger zone in 1,300′ conduit. Hot Lake area will be drained. Measures are expected to reduce normal boron content to 0.33 p.p.m. and to keep monthly peak in summer (irrigation season) below 0.46 p.p.m. Dilution with Mono supply will reduce ave. content to 0.22 and monthly max. to 0.33 p.p.m. Formerly, max. during summer frequently reached 1.5 p.p.m.—*R. E. Thompson.*

Sewage Treatment Coupled With Irrigation. F. M. Veatch. Eng. News-Rec. **124:** 24 ('40). Recently completed sewage-treatment plant of Pueblo, Colo., is described. Effluent is discharged into Arkansas R., entire flow of which is appropriated for irrigation, and principal objective of plant is to prevent deposition of suspended matter in river and irrigation canals. Plant, capac., 20 m.g.d., consists of screens, grit chambers, pre-aeration tanks for grease separation and for mixing when a coagulant is employed, clarifiers of center-feed, peripheral overflow type, heated sludge-digestion tanks equipped for gas collection, and sludge drying beds. Sludge gas is utilized in gas engines, butane being used as a standby fuel. Digestion tanks are heated by circulation of engine jacket water. Cost of plant was $465,300, of which $68,300 was for connecting sewers.—*C. A.*

Irrigation by Ground Water. Roberto Stefanon. Ann. Lavori Pub. **77:** 855 (Aug. '39). Irrigation becomes economical whenever gain accruing from increased agricultural production exceeds cost of supplementary water supply. District under discussion is to left of Tagliamento R., near northern limit of central plain of Friuli. It is underlaid by great depth of water-bearing sands and gravels, through which a strong current is constantly flowing from north to south, fed largely, no doubt, by Julian Alps, Province's northern boundary. Slope of surface is about 3 or 4 per thousand, while that of underlying water table is only about 1.5 to 2.5; so that, at some little distance south, water reaches the surface, forming a region of swamps and rivers, discharge from which is about 100 cu. m. per sec. On other hand, depth of water table below surface increases to north. Fluctuations in level of water table are considerable, especially in dry years, but there is always abundance of ground water at depths varying from 3.5 to 8.5 meters. Soil is such that its productivity is governed almost entirely by precipitation. Mean annual rainfall is 1300 mm., of which 250 mm. belongs to critical growing season, June to Aug. But in dry years, which occur 2 or 3 times each decade, June to Aug. rainfall is only about 80 mm. At all times, distribution of rainfall is capricious, and should a spell of fine, rainless weather be prolonged to 20 days, total failure of staple crop, maize, would ensue. Illustrations given of adjoining maize plots, one irrigated, other not, bring home forcibly very serious hazard involved. 2 areas, each of 400 ha., about 5 km. apart, were selected for irrigation. Each was divided into 5 sections, and each section has its own well, pumping system, and irrigation channels. Each well has its own metering system and is adjusted to deliver 150 liters per sec. Very careful calculations, details given, indicated that by allowing to each hectare in turn once weekly for two consecutive hr. entire output of well, adequate irrigation would be secured. Wells are circular structures of reinforced concrete, of 2 m. internal and 2.4 m. external diam. They are built up of rings 20 cm. high, and bottom of each ring, except at 3 places where it rests upon ring below, is chamfered off off to leave clear space 1.5 cm. high externally and 2 cm. internally, through which water can enter. Additional water ingress is provided by 24 longitudinally perforated bricks, 20 cm. long, set radially at equal intervals. Vertical reinforcement is carried up through vertically aligned supporting points.

Bottom of the lowest ring tapers sharply to external cutting edge reinforced with mild steel. Well is sunk by excavating interiorly with 0.250 cu. m. orange-peel bucket. No difficulty is experienced until water is encountered, when progress is sometimes slowed down or even brought to a standstill by caving in of earth on all sides. Standard depth for concrete wells is 15 m., but not all were sunk so far. Additional water-bearing capacity, if needed, is secured by sinking from bottom of concrete well a perforated-tube well 10 m. long by 55 cm. in internal diam., and, if this proves insufficient, an extension 9 m. long of 47.5 cm. internal diam. In all cases a yield of 150 liters per sec. even at extremes of drought was made secure. Details of the 10 wells are given. Underlying sands and gravels vary greatly in permeability both vertically and horizontally. Unless electric power had been available, cost of pumping would have been prohibitive. Rather stringent requirements are: (1) flow of water shall be kept constant, notwithstanding considerable fluctuation in level of water table, and without any undue expenditure of current; and (2) pumping service must be uninterrupted and absolutely automatic. Comparatively limited field of efficiency of centrifugal pump determined selection of multiple-stage turbine pumps, which were set so low that even at times of severest drought at least one unit is fully submerged. Common vertical axis of the turbines extends to surface and is there direct-coupled to vertical motor. Minimum number of stages is 2; maximum, 4. Motors vary from 14 to 24 h.p. Applied current is 220-volt, stepped down from 10,000 volts. Implied in second requirement is, that pump, once started, is able to take care of itself and, in case of interruption to current, to start up again automatically, immediately current is restored, and without priming. Standard type of asynchronous motors with centrifugal rheostat are in use; double squirrel-cage asynchronous type with rotor in short circuit is under consideration for future. Light check-valve at mouth of discharge protects pumps from back-flows in case of current failure. Valve under manual control, by which part is returned to well, is provided in case flow should become excessive. It is hoped in future installations to make this service automatic. Uppermost meter of concrete wall is poured in one piece and squared off to support cabin housing the pump. Transformer house is built at a few paces distant for sake of more solid foundation. Simple apparatus, easily within capacity of intelligent rural laborer, has proved adequate. Summing up: 10 pumping plants, 54 km. of irrigation channels, 1010 irrigating outlets, 240 siphons, and a few special items have been constructed. 4 yr. experience has shown that leakage from channels is considerable and that if they were concrete lined, each well would irrigate 100 ha. instead of 80. Power cost is made up of fixed annual charge per kw. of power installed and charge per kwh. for current consumed. Amortization of capital (75% advanced by govt.) has also to be provided for. Total annual charge per hectare is now upwards of L.130, and may reach L.140 as use of water intensifies. Farmers are enthusiastic in support, and requests for extension of system are many and urgent. Level of crop production is maintained at that of most favorable seasons in past, and livestock are no longer a perilous gamble with a nightmare of forced sale at ruinous prices hanging over them in case of a dry summer.—*Frank Hannan.*

Notes on Soil Erosion in the Emilian Apennines. GIOSAPHAT MONTANARI. Ann. Lavori Pub. (Rome) **77**: 493 (May '39). Detailed report, with 5 maps and 4 illustrated views, of a lengthy investigation, centering chiefly on gathering ground of Serchiello Torrent, a tributary of the Serchia, in turn a tributary of the Po. Strata exposed, vegetation covering surface, or lack of it, altitude, steepness of slopes, aspect with respect to meridian, rainfall and especially its intensity, are all important factors. Has been found possible to measure with some degree of accuracy volume of solid matter carried down and to trace its origin. Among points of more than merely local significance is recorded an occurrence illustrating risks often unwittingly run by alteration, even small, of natural regime. Of two of smaller streams which, converging, go to make up Serchiello, one had steeper and shorter course, and its flood crest consequently used to pass down well in advance of that of other, but after some amelioration work had been done, flood crests reached the confluence more nearly simultaneously, so that from that point down, for a distance of many kilometers, crest of every flood reached greater heights than had been known before, causing much destruction.—*Frank Hannan.*

Pages 2099 ff., the Resumé of the 1940 Convention and Section Meetings and the Index of the 1940 Journal, will be found immediately following the Tentative Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs.

The 1940 Convention

THE Association held its Sixtieth Convention in Kansas City, April 21–25, 1940. It is of interest to note that its first meeting (1881) was also held in Missouri—at St. Louis. Three other conventions have been held in St. Louis (1904, 1918 and 1930) but no prior convention has been held in Kansas City.

All technical and committee meetings, as well as the exhibits, were held in the Municipal Auditorium. The Continental, Muehlebach, Phillips and President Hotels were co-headquarters for housing, although the other principal hotels of the city were freely called upon to care for those who were unable to find accommodations in the headquarters group.

For the fourth successive year, the paid registration exceeded 1,000. This year it reached the all-time peak of 1,467. The record for the past twelve years is as follows:

Year	*City*	*Total Registered*	*Year*	*City*	*Total Registered*
1929	Toronto	1,104	1935	Cincinnati	901
1930	St. Louis	1,021	1936	Los Angeles	891
1931	Pittsburgh	1,076	1937	Buffalo	1,140
1932	Memphis	712	1938	New Orleans	1,123
1933	Chicago	660	1939	Atlantic City	1,290
1934	New York City	891	1940	Kansas City	1,467

The Convention Management Committee consisted of:

Representing the A. W. W. A.

Wm. J. Orchard, *Chairman*
S. F. Newkirk, Jr.
N. T. Veatch, Jr.

Representing the W. W. Mfrs. Assn.

Clinton Inglee
J. H. Smith

Ex-Officio

J. Arthur Jensen, Pres., A. W. W. A.
Harry E. Jordan, Secy., A. W. W. A.
Linn H. Enslow, Chr., Publ. Comm., A. W. W. A.
W. F. Rockwell, Pres., W. W. Mfrs. Assn.
John A. Kienle, Secy., W. W. Mfrs. Assn.

Missouri Valley Section Committees. Regional interest in a convention, so effective at Atlantic City in 1939, was further demonstrated to be valuable in 1940. Special Missouri Valley Section Sub-Committees and their chairmen were:

General Host Committee	Bernard L. Ulrich
Ladies Entertainment Sub-Committee	Mrs. R. E. McDonnell
Ladies Rendezvous Committee	Mrs. Jos. W. Ivy
Convention Attendance Committee	Earle L. Waterman
Local Transportation Committee	Jos. W. Ivy
Water Works Get-Together	Dale L. Maffitt
President's Reception and Dance	John C. Detweiler
Ladies Tour of City	Mrs. Ira T. Collar, Jr.
All Section Dinner	W. Victor Weir
"Red Gulch Jamboree"	John A. Strang
Ladies Luncheon Bridge	Mrs. M. P. Hatcher
Dinner-Dance	D. L. Erickson

Every feature of this arrangement of regional sub-committees worked satisfactorily. It is increasingly evident that the successful handling of ladies events depends upon the work done by the local chairman of the ladies group and the work done by ladies residing in or near the convention city. The General Host Committee greeted members as they came to the convention hall to register and rendered effective service in expediting the registration. This task is an important one.

President Jensen, in his address at the opening of the Convention said, in part:

"The value of the A.W.W.A. to the water works man and his community is continually increasing, and it is becoming better qualified to serve the membership in its endeavor to meet the needs of an industry whose problems are becoming ever more intricate and exacting. Each year brings a continuing array of new water problems to be mastered.

"The A.W.W.A. endeavors to foster a recognition of the importance of water supply in the community, protection against political interference with properly qualified operators, to promote educational work for the benefit of the membership and to encourage training for the various special branches of the service.

"The value of A. W. W. A. work is enhanced by the set-up of some

50 committees, each devoted to some phase of water works. The Water Works Practice Committee has, this year, submitted a progress report to the Board of Directors covering 58 topics covering standard specifications, methods, and specific practice. Each subject is a matter of special study by a committee selected for the purpose, and conclusions are reached only after painstaking efforts on the part of men who are willingly giving their time and energy to their assignments.

"At the present time serious interest is taken in the study of safety work relating to hazards in water supply created in past construction and by no means absent in present practice. These appear in cross-connections, defects in distribution layouts and the numerous instances of danger in plumbing construction and fixtures. Every effort will be taken in the large task of elimination of these troubles.

"There is continual advancement in the manufacturing field and notable improvements in material and equipment especially in quality and design. Much research work is being done and the manufacturer is showing an earnest effort and interest in the betterment of his product that will be beneficial to the water industry."

Convention Program. The development of the schedule of papers was in charge of Chairman L. H. Enslow and his Publication Committee of fifteen. The presiding officers met with the Secretary in advance of the convention and were given advice concerning methods of handling the sessions. A set of instruction sheets for presiding officers; a set of comment sheets for presiding officers to use, one for each paper; a set of instruction sheets for the monitors; and a sheet for record of attendance at each session were prepared and made available at every session. Nothing developed during the convention to indicate the advisability of changing the general plan of the meetings.

It is important to note that, with a total of 1,033 men registered at Atlantic City, the peak attendance at any hour during the sessions was Tuesday morning at 11:30. At that time, 347, or 33 per cent of the total (men), were in the meeting rooms. At Kansas City, the peak was reached at 4:30 P.M. on Tuesday, when 577 persons were in the meeting rooms. This was 45 per cent of the 1,275 total men registered. This, in itself, is testimony of the improving quality of the papers and discussions and is an enviable record for any non-professional association. Even on the final afternoon of the Kansas

City Convention, there were twice as many in the meeting as there were at Atlantic City.

Entertainment. General entertainment plans were in the hands of Clinton Inglee. The chairman and members of the regional co-operating committees rendered unusually fine service. Mrs. R. E. McDonnell directed the local entertainment for ladies, combining, in enviable fashion, an ability to manage events with a gracious personality. The addition of the Cheyenne Mountain School Dancers to the Monday evening program was distinctly worthwhile.

The Tuesday evening address by Federal Security Administrator Paul V. McNutt was directly related to the interests of water works men and brought credit both to the speaker and to the Association. Some members misunderstood the quality of the address, thinking that it would be political, and deprived themselves of the opportunity to participate in an event in which the Association should take pride.

Exhibits. If for no reason other than the facilities for exhibits, the selection of Kansas City and its Municipal Auditorium as the site of the 1940 convention was fully justified. One hundred and forty-seven booths were set up and occupied by 99 exhibits. At Atlantic City there were 129 booths sold to 88 exhibitors. The available space in the Kansas City auditorium made it possible to occupy about 30,000 square feet with the exhibits and aisles. This made for the comfort of those who wished to study the equipment and resulted in the satisfaction of the exhibitors with the attention given their equipment.

The opening of the exhibits for inspection at noon on Sunday was definitely worthwhile. The majority of persons who attended the convention reached Kansas City on Sunday and spent some time about the convention hall getting acquainted with the exhibits and greeting old acquaintances.

Thanks to the energy of E. L. Filby of Kansas City, there was also available for study at the end of the exhibit area a display of water department publicity material. Such properties as the American Water Works and Electric Company, East Bay Municipal District, Indianapolis Water Company, Springfield (Ill.), Detroit, Des Moines, Los Angeles, Louisville, St. Paul and other departments made available for study files of material which had been prepared for the furtherance of publicity and public relation activities in their respective areas.

Publicity. The experiences in recent years in obtaining local or regional publicity have been varied. This year it was possible to arrange for the services of a newspaper-public relations man who came to Kansas City, contacted the newspaper offices and promoted a series of interviews with prominent members of the A.W.W.A. Radio Station WDAF arranged a round table broadcast on Wednesday afternoon. Messrs. Jensen, Dugger, Rockwell, Orchard, Howard and Hurlbut participated. It was worthwhile.

Local Inspection Trips. The water departments of the Missouri and Kansas, Kansas Cities, arranged for transportation to the filtration and pumping stations of their respective cities on Wednesday afternoon. About 700 made the trip and found it informative.

Norman J. Howard, in assuming the office of President of the A. W. W. A. for 1940–1941, said in part: "Each year sees the introduction of more stringent requirements relative to experience and qualifications of those engaged in engineering practice. It seems reasonable to assume that at some time in the future, the licensing of those associated with water works operation and management will become compulsory rather than voluntary. In many parts of the country, the organization of water works operators associations has been, and still is, a live issue. Some feel that such bodies could best be controlled by A. W. W. A. sections since the training in all probability is given by Association members and that the ultimate aim would be the certification of operators.

"While political interference in public appointments, particularly those associated with water supply, is still evident, conditions have improved. It is the policy of A. W. W. A., by virtue of its rapidly increasing influence, to take steps where necessary, to protect the interests of its membership at large and to give leadership in the sponsoring of pension schemes and retirement allowances for water works employees. Close cooperation with the Water Works Manufacturers Association, such as has been increasingly evident in more recent years, should do much generally to publicize the activities and importance of Association affairs. Through this medium the sphere of influence can be greatly expanded. Extending participation and cooperation with other organizations must greatly enhance both the national and international status of A. W. W. A.

"We can look forward to the future with ever increasing confidence."

Presentation of Awards

Honorary Membership was conferred upon Messrs. George H. Fenkell, James E. Gibson, John A. Kienle, and Herbert M. Lofton. The citations were:

George H. Fenkell, of Almont, Michigan, retired General Manager, Board of Water Commissioners, Detroit, Michigan; the chief of that city's water department during a period of rapid expansion which called for the combination of high engineering ability and management skill; A. W. W. A. member since 1920; President, 1931.

James E. Gibson, of Charleston, South Carolina, General Manager of that city's water department; a water works executive who has the fullest respect of his community; who has guided many younger men into effective service to the water works field; A. W. W. A. member since 1922; President, 1928.

John A. Kienle, of New York, N. Y., Vice-President of Mathieson Alkali Works, Inc.; the Secretary of the Water Purification Division for the first five years of its existence; for many years the Secretary and a guiding spirit of the Water Works Manufacturers Association; member of the A. W. W. A. since 1909; Director, 1936–8, 1939–.

Herbert M. Lofton, of Chattanooga, Tennessee; formerly Superintendent of Water Works of Savannah, Georgia; founder and General Manager of the Columbian Iron Works; responsible for the development of many useful improvements in water works equipment; A. W. W. A. member since 1895.

The John M. Diven Medal, annually awarded to the member whose services to the Association are deemed most outstanding, was presented to William V. Weir with the following citation:

William Victor Weir, Superintendent-Engineer of the St. Louis County Water Company, University City, Missouri, for his outstanding work as chairman of the Association's committee on "Distribution System Records"—one of his many services to the water supply field.

The John M. Goodell Award, for the best paper published in the Journal of the Association, was presented to:

Thomas H. Wiggin, Consulting Engineer, of New York, N. Y., and *Melvin L. Enger*, Dean of Engineering, University of Illinois, Urbana, Illinois, for their scientific contributions in the preparation

of the paper "A Proposed New Method for Determining the Barrel Thickness of Cast-Iron Pipe," which was published in the Journal of the Association in May, 1939. This paper was selected because it represents painstaking research, scholarly interpretation of results, adequate technical analysis and presentation of matter of great importance in the water works field.

George W. Fuller Memorial Award certificates were presented to the following members:

California Section—*Raymond Freeman Goudey:* In recognition of his outstanding service in the conduct of short schools for water works operators; for advancement of certification of operators; for laying the foundation for hotel sanitation standards for use of the California Section; for his work in diversion of carbon dioxide from the Soda Springs Tunnels of the City of Los Angeles; and, for improving the technique of the water works laboratory of that city.

Canadian Section—*Theodore Joseph Lafreniere:* For conspicuous leadership in the fields of water purification, supervision of public water supplies, control of water-borne diseases and the general betterment of those environmental factors associated with public health; and for persistent support of the activities of this Association.

Four States Section—*Carl Adam Hechmer:* In recognition of his outstanding services and untiring efforts in the Four States Section, A. W. W. A., and in the Maryland-Delaware Water and Sewerage Association; as chairman of the committee on short courses of instruction for water and sewage plant operators conducted at the University of Maryland under the joint sponsorship of the two associations and the Maryland State Department of Health; and for meritorious work in the operation and maintenance of the water works systems in the Washington Suburban Sanitary District.

Indiana Section—*Frank Carver Jordan:* For his many years of loyal service to every interest of the water works field; for his devotion to the highest standards of management; and for his inspiring leadership of the men associated with him.

Kentucky-Tennessee Section—*Howard Dean Schmidt:* For his activity in the conduct of schools for water works plant operators and in the inauguration of a program for the certification of water works operators in Tennessee.

Michigan Section—*Laurence George Lenhardt:* For his able, energetic and effective leadership in promoting through the Michigan State Legislature, during the 1939 session, the passage of legislation which assists the water departments in their efforts to furnish an adequate supply of pure and wholesome water at the lowest possible cost and which provides means for preventing serious losses to Michigan water departments in their collection of just accounts.

Missouri Valley Section—*August Vincent Graf:* For his research and contributions to water purification and water works practice and his generous assistance to younger men in the water works field.

New Jersey Section—*Lincoln Van Gilder:* For meritorious service to the American Water Works Association and for service to the Atlantic City Water Department over a period of 34 years. During this period of service he has contributed valuable service in planning and executing extensive improvements to the water supply system of that city.

New York Section—*Charles Raymond Cox:* For outstanding educational work among water works operators, particularly through the development of in-service training courses; and for his many useful contributions to the literature on water purification.

North Carolina Section—*Herman Glenn Baity:* For long and effective years of official service to the North Carolina Section of the American Water Works Association as secretary-treasurer and president; for noteworthy service to the State and its municipalities as an engineer with the State Board of Health; and for outstanding service to North Carolina as State P.W.A. Engineer during which time many excellent water plants were built.

Rocky Mountain Section—*Benjamin Varnum Howe:* For his outstanding work in promoting the membership of the Rocky Mountain Section and his untiring and conscientious management of Section affairs.

Southeastern Section—*Paul Weir:* For his experimental interest in numerous materials in an effort to improve the process of water purification; for his study and report on the corrosion of pipe of various kinds and tests on the standard and special types of protective coating and enamels on cast-iron and steel; and for his untiring efforts to stimulate interest in, and to build up the Southeastern Section.

Southwest Section—*Leroy Henry Scott:* For the following outstanding accomplishments: development and application of submerged combustion recarbonation equipment; and development and application of the Scott-Darcy process of ferric chloride production.

Virginia Section—*Marsden Churchill Smith:* For his engineering ability; his investigative turn of mind leading to useful research and development; his efficient management of municipal property entrusted to his care; and his inspiration in organization and leadership in the Virginia Section.

West Virginia Section—*Perkins Boynton:* For his skill as a laboratory worker, and for his many years of successful and untiring efforts in training younger men in water treatment processes.

Wisconsin Section—*Louis Frederick Warrick:* In recognition of his outstanding service to the Wisconsin Section as past chairman and perennial chairman of the Health Session; for his effective work in increasing the purity of Wisconsin water supplies; and for his meritorious work in connection with stream pollution abatement.

No Fuller Memorial Awards were made by the Florida, Illinois, Minnesota, Montana, New England, Ohio, Pacific Northwest, Western Pennsylvania Sections during the period between the Atlantic City and the Kansas City Conventions. Awards made by Sections which held spring meetings in 1940, after the time of the Kansas City Convention, will be formally presented to the recipients at the time of the Toronto Convention and recorded in this JOURNAL at the close of 1941.

The Nicholas S. Hill Cup, awarded annually to the Section making the greatest percentage gain in membership from one general convention to the next, was won by the Southwest Section. Its gain was 73.04 per cent. Following in order were the North Carolina Section (33.33 per cent gain) and the Western Pennsylvania Section (21.35 per cent gain).

The Henshaw Cup, awarded annually to the Section having present at its annual meeting, the greatest per cent of its membership, was won by the Wisconsin Section. At its 1939 meeting, 89.79 per cent of its membership attended. There followed the West Virginia Section (88.54 per cent) and the North Carolina Section (88.19 per cent).

The Old Oaken Bucket was again given to the California Section as the Section having the largest total membership. This trophy will remain in the possession of the California Section until some other Section achieves a greater membership total.

Schedule of Papers and Reports

General Session—9:30 A.M.—April 22, 1940

Association Business Meeting
General Announcements
Special Reports of Water Works Practice Committees
Panel Discussion—Specifications for Pipe for Water Works Use
Malcolm Pirnie, Thos. H. Wiggin, Wm. W. Hurlbut, L. R. Howson, Wm. W. Brush

Plant Management Division—2:00 P.M.—April 22, 1940

A Program of Equipment Replacement ..... A. M. Brenneke
Discussion by ..... George S. Rawlins
An Engineer's Viewpoint After Four Years' Experience in Public Life
Frank O. Wallene
Present Status of Cross-Connection Control ..... E. Sherman Chase
Depreciation of Cast-Iron Water Mains Related to Actual Service Lives
Reeves Newsom and E. H. Aldrich
Drilling Wells and Installing Well Pumps—A Round Table Discussion

Water Purification Division—2:00 P.M.—April 22, 1940

Committee Reports:
Activated Carbon Research ..... Mathew M. Braidech
Chloramination ..... F. W. Gilcreas
Co-ordination of Methods of Water Treatment and Laboratory Control
Geo. D. Norcom
Methods of Determining Fluorides ..... A. P. Black
Discussion by ..... W. R. Willis
Standards for Purification Plant Operation ..... Edw. S. Hopkins

General Session—9:30 A.M.—April 23, 1940

Kansas City's (Kan.) New Pumping Station
C. S. Timanus and Robt. Lee Baldwin
The Wichita Water Supply Improvements ..... R. E. Lawrence
Pumping and Related Equipment Used on the Mono Craters Tunnel Project
Stephen M. Dunn
Novel Design Features of the Lansing (Mich.) Water Conditioning Plant
Claud R. Erickson
Missouri Valley Section Business Meeting

Finance and Accounting Division—9:30 A.M.—April 23, 1940

A Review of Lien Laws in the United States (A Committee Report)
H. L. Meites
A Customer's Service Bureau ..... Hal F. Smith

The Texas Fire Insurance Department of the Board of Insurance Commissioners .... Albert R. Davis
Special Rates and Free Water Service—A Round Table Discussion
Led by Dale L. Maffitt

General Session—2:00 P.M.—April 23, 1940

(Symposium on Steel Pipe)

Construction and Tests of High Pressure Steel Water Supply Line for Colorado Springs .... E. L. Mosley
Behavior of Flexible Steel Pipe Under Trench and Fill Loads
Russell E. Barnard
Utilization of Steel Pipe for Water Supply and Distribution Systems
H. R. Redington
Types of Protective Coatings Used for Protection of Interior and Exterior Surfaces of Steel Water Lines .... Deming Bronson
Service Life of Coal-Tar Enamel Protective Coatings .... Harry Hayes

Water Purification Division—2:00 P.M.—April 23, 1940

Panel Discussion—Controlling Tastes and Odors (Experiences with ammonia, activated carbon, copper sulfate and super-chlorination)
Louis J. Alexander, Horace A. Brown, C. K. Calvert,
Wm. U. Gallaher, Walter Strockbine, N. A. Thomas,
A. E. Griffin, E. A. Sigworth
Summary of above .... J. R. Baylis

General Session on Management—9:30 A.M.—April 24, 1940

Organizing to Prevent Fires .... Percy Bugbee
The Engineer Looks at Management .... Robt. E. McDonnell
The Public Service Commission's Part in Water Plant Management
Robt. A. Nixon
The Water Board as a Factor in Good Management .... Henry S. Nollen
Discussion by .... H. A. Van Norman and George J. Rohan

Water Purification Division—9:30 A.M.—April 24, 1940

Corrosion Prevention by the Use of Sodium Hexametaphosphate
Edw. C. Trax and Robt. Spurr Weston
The Physiological Effects of Sodium Hexametaphosphate .... K. K. Jones
Depreciation of Water Quality in Distribution Systems
Bacterial Quality .... Norman J. Howard
Chemical and Biological Quality .... A. M. Buswell and Max Suter

General Session With Water Purification Division—9:30 A.M.—April 25, 1940

The Water Quality Requirements of the Soft Drink Industry .... Kennon Mott
Active Problems in Water Purification .... Paul Hansen
Dry Feed Chemical Equipment (What is wrong with present specifications?)
L. E. Harper
Recent Changes in Patent Law .... Arthur C. Brown
Discussion by .... D. L. Erickson

Finance and Accounting Division—9:30 A.M.—April 25, 1940

Experiences With a Department Newspaper . . . . George S. Bonn
The Management of Combined Municipal Utilities . . . . O. E. Eckert
Discussion by . . . . F. W. Martin
Efficiency in the Management of Water Works Properties
Leonard N. Thompson
Legal Decisions Relating to Water Distribution . . . . Frank A. Marston

Plant Management Division—2:00 P.M.—April 25, 1940

Cathodic Protection of Water Tanks . . . . E. E. Norman
Lining Cast-Iron Water Mains in Place With Cement Mortar at Charleston, S. C. . . . . J. E. Gibson
The Effect of Internal Pipe Lining on Water Quality . . . . Paul Weir
Modern Hypochlorites . . . . John A. Logan and Walter L. Savell

Papers Scheduled at Section Meetings

There follows a summary-listing of papers scheduled for presentation at Section meetings during 1940. The locations and dates of the 1940 Section meetings are shown on page 2123. A record of the number of members and the attendance at Section meetings in 1938, '39 and '40 is presented on page 2124. Section officers who were elected at meetings held during 1940 and who will be holding office on January 1, 1941, are shown on page iv of this JOURNAL.

California Section—Scheduled Papers

Activities of the Purification Division	Norman J. Howard
Welcome to Los Angeles	Mayor Fletcher Bowron
The Use of Softened Water for Home Gardens	O. C. Magistad
Some Recent Observations on Bacteriological Corrosion of Iron	T. D. Beckwith
Description of Los Angeles Water Supply System	H. A. Van Norman
Economies and Performance of Natural Gas-Engine-Driven Pumps	George H. Dieter
Erosion Control on Reservoir Drainage Areas	C. J. Kraebel
The Problem of Domestic Water With Mutual Water Companies	L. E. Blakeley
Symposium on Water Distribution System Extensions:	
Cost of Pipe Installations	L. L. Farrell
Financing of Extensions	E. F. Dandridge
Water Quality Requirements for Various Types of Industries	Gilbert T. Bently
Recent Bacteriological Observations in the Use of Sodium Hexametaphosphate	Carl Wilson and Henry C. Myers
The Use of Cement Joints to Improve Water Quality	Robert M. Ebaugh
Address—"Your Association"	Norman J. Howard
Symposium on Cross-Connections, Back Flow and Back Siphonage Protection:	
Practical Aspects	Ray F. Goudey
Legal Aspects	Robert E. Moore, Jr.
Distribution Reservoirs—Capacity Requirements and Design	Robert C. Kennedy
Earth Reservoir Embankments With Road Oil Linings	Duncan A. Blackburn
Joint Round Table on Water Works Subjects:	
General	Samuel B. Morris, Chairman
Water Purification	L. J. Alexander, Chairman

Canadian Section—Scheduled Papers

Chairman's Address .... C. J. DesBaillets
Methods and Results of Testing Pumping Equipment
R. W. Angus and C. J. DesBaillets
Industrial Water Supplies in Canada .... H. A. Leverin
Sewer Rental Financing .... Wm. Storrie
Photo-Cell Control of Water Chlorination .... J. H. Harrington
Determination of Phenols in the Presence of Sulfides
L. S. Renzoni and A. V. De Laporte
Guided Discussions:
Departmental Organization and Financing .... O. H. Scott, Chairman
Water Pressures in Distribution System .... L. F. Allan, Chairman
Water Service Pipes .... R. J. Smith, Chairman
To What Extent Do Fire Protection Requirements Govern the Size and Costs of Distribution Systems? .... R. L. Dobbin, Chairman
War-Time Protection of Public Works .... E. V. Buchanan, Chairman
Disinfection of New and Repaired Mains .... W. E. MacDonald, Chairman
Meter Maintenance .... J. W. Peart, Chairman

Cuban Section—Scheduled Papers—First Meeting

Welcome to the Newly Authorized Section .... Norman J. Howard
Reply and Address .... Eduardo J. Chibas
Luis Morales

Florida Section—Scheduled Papers

Address of Welcome .... E. E. Anders
Response for Florida Section .... George F. Catlett
American Water Works Association Affairs .... Norman J. Howard
The Water Treatment Plant of the Fernandina, Fla., Mill of Rayonier, Inc.
Charles E. Richheimer
The New Bradenton Water Treatment Plant .... Charles K. Dodd
Use of A. W. W. A. Standard Specifications by Operators .... William W. Brush
The Corrosion of Steel Water Storage Tanks and the Cathodic System of Protection .... M. B. Randle
Concrete Coating for Underground Piping .... J. Herman T. McGee
Protective Linings and Coatings for Water Mains .... William F. Horsch
Threshold Odor Test .... Henry Laughlin
Crenothrix and Related Iron Bacteria in Florida Waters .... S. W. Wells
Experiences With the Accelerated Lime-Soda Softening Process
A. S. Behrman
The Mechanics of Filter Bed Agitation .... Fred E. Stuart
New Methods of Water Analysis by the Electric Eye .... W. O. Widener
Municipal Water Softening .... Eskel Nordell
Fundamental Principles of Industrial Waste Disposal .... Henry J. Miles

Four States Section—Scheduled Papers

Welcome to Wilmington .... Hon. Walter W. Bacon, Mayor
Flood Forecasting Service in Pennsylvania .... John W. Mangan
Factors in Control of Reservoir Silting .... Carl B. Brown
Discussion of two preceding papers .... Led by Harry R. Hall

Symposium on Filter Washing: ......Led by Carl J. Lauter
Length of Wash With Respect to Effluent Clarity ......Edw. S. Hopkins
Measurements of Filter Washing Rates and Sand Expansion ..Harry Krum
Why Sand Expansion, Not Velocity, as an Indicator of the Filter Wash
Roberts Hulbert
Low Rate Wash and Its Applications ......Chas. Trowbridge
Surface Wash Types, Their Relative Efficiency ....Philip O. Macqueen
Anthrafilt and Anthrafilt-Sand Filter Washing ......Homer G. Turner
Theory of Filter Bottom Design With Respect to Effect on Washing
Fred Haddock
Quality of Municipal Ground Water Supplies in Delaware ....R. C. Beckett
Discussion ......Led by W. D. Collins
Insurance Requirements for Water Works Properties ......R. F. Goodhue
Discussion ......Led by Charles Haydock
Distribution System Maintenance Practice ......Fred E. Muser

Illinois Section—Scheduled Papers

Control of Well Drilling ......W. D. Gerber
Cross-Connections ......F. M. Dawson
Explanation of Cross-Connection Exhibit ......John G. Mitchell
Discussion of Exhibit and Prof. Dawson's Paper ......Herbert Moore
Developments in Licensing ......H. E. Babbitt
Tuning Up the New Milwaukee Filtration Plant ......J. E. Kerslake
The South District Filtration Plant in Chicago ......L. D. Gayton
Electrical Grounding to Water Pipes ......Walter A. Peirce
Water Quality Standards ......John R. Baylis
Superintendents' Round Table: ......Led by H. E. Hudson, Jr.
Water Treatment ......F. L. Coventry
Pumping Equipment ......W. R. Gelston, Jr.
Distribution System ......H. S. Merz
Meters ......L. V. Trentlage

Indiana Section—Scheduled Papers

Address of Welcome ......Dr. Edward C. Elliott
Modern Trends in Legal Liability ......G. R. Redding
Control of Water Well Drilling ......L. S. Finch
Discussion ......Frank R. Shaw
Experiences with Super-Chlorination ......P. C. Laux
Use of Sodium Hexametaphosphate in Water Treatment ......T. R. Lathrop
Discussion ......W. A. Oeffler and Philip Rector
Round Table Discussions ......M. H. Schwartz, Chairman
Leak Detection ......H. W. Niemeyer
Ownership and Maintenance of Service Lines and Curb Boxes
William C. Shoemaker
Special Rates and Free Water Service ......W. H. Durbin
Cold Weather Problems ......C. L. Link and A. R. Klein
Testing Large Meters in Position ......F. P. Stradling
Round Table Discussions ......J. C. Matthews, Chairman
Taste and Odor Problems ......J. C. Vaughn
Combating Discoloration ......C. D. Adams
Maintenance of Filter Controls and Beds ......Neil Kershaw
Experiences with 100 Milliliter Plantings ......R. A. Hoot

So This Is Communism .... Robert Phillips
Research in Filter Underdrains .... W. E. Howland
Cathodic Protection for Tanks .... W. C. Mabee
  Discussion .... T. H. Wiggin
The Kind of a Boss I Like to Work For .... Lorenzo Semple, Jr.
Public Relations .... John C. Mellett and Miller Hamilton
Value of Records .... L. A. Geupel

Kentucky-Tennessee Section—Scheduled Papers

Address of Welcome .... Hon. T. Ward Havely, Mayor
Response .... C. M. McCord
Address .... Harry E. Jordan
Protection of Water Works Properties From Sabotage .... F. C. Dugan
  Discussion .... L. S. Vance
Rating of Public Water Supplies .... R. P. Farrell
Small Diameter Cast-Iron Pipe .... B. F. Crabbe
Maintaining Water Service in Sub-Zero Weather .... Elwood Farra
Importance of Electric Power to Water Pumping Plants .... F. I. Fairman
Corrosion Control .... C. E. Trowbridge
Break-Point Chlorination .... A. T. Andrews
New Developments in Filter Wash .... J. Stephen Watkins
Certification of Water Works Plant Operators .... James H. Fry
Round Table Discussion:
  Filter Plant Operators School .... R. R. Harris
  Copper Sulfate Treatment .... R. O. Naser
  Well Water Treatment .... J. K. Latham
  Pre-Chlorination .... John J. Quinn

Michigan Section—Scheduled Papers

Address of Welcome .... Mayor Walter C. Sadler
" " " .... Alexander G. Ruthven
News of the Field .... R. J. Faust
Why and How to Sterilize Jute and Pump Packing .... O. E. McGuire
  Discussion .... H. B. Huntley
Experimental Studies in Ozonation .... J. C. Richardson
Annual Reports .... Murray M. Smith
Round Table Discussions:
  Water Meter Experiences .... Led by George Golden
  Experiences in Cathodic Protection .... Led by E. E. Norman
  Insurance Practice for Water Works Utilities .... Led by H. E. Allen
Present Status of Activated Carbon Evaluation .... Douglas Feben
pH Correction at Highland Park .... Irving L. Dahljelm
Further Developments in Special Media .... W. L. Mallmann
The Ann Arbor Water Softening Plant:
  History and Development .... Harrison H. Caswell
  Design .... Louis E. Ayres
  Operation .... Harry E. McEntee

Minnesota Section—Scheduled Papers

Address of Welcome .... Mayor John H. McDonough
Legal Liabilities of Water Utilities .... J. Arthur Jensen

Sludge Control and Recovery From Water Softening ..... Howard Sowden, Jr.
A Study of Particle Size in Turbidity Standards .... Ole Forsberg
Round Table Discussion: .... Led by R. A. Thuma
The Licensing of Water Works Operators .... U. J. Seibert
Trends in Water Treatment .... Arthur F. Mellen
Water Conditioning for Other Than Sanitary Purposes ..... R. V. Lucas
Service Connections .... R. E. Watters
Problems Encountered in Electric Grounding to Water Pipes
A. H. Hanson
Pumping Equipment .... Geo. J. Poole
Round Table Discussion: .... Led by Arthur F. Mellen
The Water Works Manager and His Community .... J. E. Young
Problems Encountered in the Small Water Works Plant .... R. M. Jenson
Frost Problems .... Charles Foster
Deep Well Development .... A. W. Bennison
Address .... Louis R. Howson
Cathodic Protection of Tanks and Underground Structures
Geo. H. Montillon
Experiences With Excess Chlorination in the Treatment of Lake Superior
Water .... Earl H. Ruble

Missouri Valley Section—Scheduled Papers

Greetings From A. W. W. A. .... Norman J. Howard
Address of Welcome .... W. S. Byrne
Response on Behalf of the Missouri Valley Section .... J. C. Detweiler
High Lights in the History of the Missouri Valley Section
Jack J. Hinman, Jr.
Twenty-Five Years of Advance in Water Works .... William W. Brush
Twenty-Five Years of Progress in Water Treatment .... Linn H. Enslow
The Superintendent of Tomorrow .... H. V. Pedersen
The Preparation of Water Works Systems for Emergencies ....
Norman J. Howard
Water Works Improvements at Creston, Iowa .... Arthur K. Olsen
Developments in Water Well Construction .... L. M. Heckman
Blacking Out Algae .... William T. Bailey
How to Make a Motion Picture of the Water Works .... W. V. Weir

Montana Section—Scheduled Papers

Address of Welcome .... Mayor H. E. Riccius
Address .... J. Arthur Jensen
Address .... William F. Cogswell
Experience in Corrosion Control at Richardton, N. D. ...... Lloyd Clark
Water Softening Plant at Miles City .... Kurt Wiel
Constructing and Operating Montana's First Modern Sewage Treatment
Plant .... J. M. Schmit
The Application of Polyphosphates to Municipal Water Supplies
Lawrence Kirk
Our Unique Light and Water Plant .... C. O. Lauer
Combating Backflow in Pure Water Systems .... G. H. Downs
Geology and Artesian Waters of Southeastern Montana .... E. S. Perry
Round Table Discussion .... Led by F. F. Palmer

New Jersey Section—Scheduled Papers—Winter Meeting

Symposium on Recreational Use of Watersheds: ..... Led by M. W. Cowles
- Out on the Good Earth ..... Lloyd B. Sharp
- Need for Increased Space for Recreation ..... William Banks
- Jurisdiction Over Sanitation of Recreational Places ..... H. P. Croft
- Private Recreational Development and Public Health ..... W. C. Mallalieu
- Regulation of Recreation on Watersheds and Reservoirs ..... Russell Van Nest Black
- Regulation by the State Water Policy Commission ..... H. T. Critchlow
- Value of Public Park Systems to Rahway Watershed ..... Mortimer M. Gibbons
- Effect of Multiple Use of Watershed on Conservation ..... C. P. Wilber

New Jersey Section—Scheduled Papers—Spring Meeting

Centrifugal Pumps ..... C. Coleman
Copper and Brass Tubes ..... C. S. Cole
Bituminous Pipe Linings ..... M. F. Abrams
Cathodic Rust Prevention ..... P. S. Wilson
Concrete Pipe Linings ..... Horace Hunt

New Jersey Section—Scheduled Papers—Fall Meeting

Hydraulics and Water Works Engineering: Part 4—Flow Measuring Devices ..... H. N. Lendall
The Work of the Federal Bureau of Investigation ..... A. P. Kitchin
Water Main Cleaning Experiences at Manasquan ..... J. Kenneth Van Brunt
Round Table:
- Statute Regulations Affecting Water Department Accounting
- The Recent Heavy Precipitation and Floods in Southern New Jersey
- Progress in the Work of the Committee on Specifications for Wells and Well Pumps
- Progress in the Preparation of New A. W. W. A. Meter Specifications
- Experience in Application of the Recently Adopted Cast-Iron Pipe Specifications
- The Wanaque Water Supply (Moving Picture)

The South Orange Zeolite Softening Plant ..... Robert Spurr Weston
The Relation of the Elected Official to the Water Superintendent ..... Frank D. Livermore
Experiences in the Lowering of Water Mains While Under Pressure ..... Harold L. Crane
How to Save Electric Power Cost by Power Factor Correction ..... Don E. Corson

New York Section—Scheduled Papers—Spring Meeting

Address of Welcome ..... Hon. Joseph Campbell, Mayor
The Watershed and Municipal Forests of Rochester, N. Y. ..... Lewis E. Kohl
Ithaca's Early Water Problems ..... E. M. Chamot
Latest Developments in Priming Centrifugal Pumps ..... Allen O. Hopper
Bacterial Pollution in the Niagara River—Part 2 ..... George E. Symons
Some Aspects of Water Handling ..... W. E. Stanley
A Small Pressure Filter Plant ..... William W. Watkins
Planned Finance for Water Works of a Small Community ..... A. Bradford Squire

The University Filter Plant ..... F. R. Georgia
Ithaca and Its Water System ..... George D. Carpenter
Round Table: The Drought of 1939 and Its Effect Upon Water Supplies of New York State ..... Led by S. T. Barker
Discussion by ..... J. McClure Wardle and Walter A. Ford
The Palmer Filter Bed Agitator ..... H. F. Wagner, Jos. E. Rehler, Fred E. Stuart and C. E. Palmer
The Use of Sodium Metaphosphates in the Prevention of Corrosion
Roland G. McDonald, A. H. Rogers, Alvin C. Southard, Owen Rice and R. I. Moran

New York Section—Scheduled Papers—Winter Meeting

An Auxiliary Supply for Mamaroneck and Harrison ..... Wm. E. Thrasher
National Defense in Public Water Supplies ..... J. L. Barron
" " " " " " ..... Tobias Hochlerner
" " " " " " ..... B. E. Sackett

North Carolina Section—Scheduled Papers

Address of Welcome ..... Hon. Graham H. Andrews, Mayor
Response ..... George S. Moore
Description of Ernest B. Bain Water Treatment Plant ..... William C. Olsen
Description of New State Laboratory of Hygiene ..... John H. Hamilton
Round Table Discussion on Grounding Electrical Circuits to Water Service Pipes:
Reviews and Reports ..... George S. Rawlins
Results of Field Investigations of Grounding ..... J. O'R. Coleman, P. W. Spence and W. R. Doar
Discussion by ..... Walter J. Seeley
Water Works Management ..... D. M. Williams
Address—"The A.W.W.A." ..... Norman J. Howard
Water Works Tools a Half-Century Ago and Today ..... William W. Brush
Pipe Symposium:
Asbestos-Cement Pipe ..... Herbert Ickler
Cast-Iron Pipe ..... Thomas F. Wolfe
Concrete Pipe (Motion Pictures)—Water Supply Line of Reinforced Concrete Pipe at Grand Rapids, Michigan ..... F. F. Longley
Round Table Discussion of Problems of Water Supply and Treatment: Led by Martin W. Swartz
Problems of Water Supply ..... D. S. Abell
Operators Discussion by ..... W. J. Parks and L. I. Lassiter
Round Table Discussion of Operating Problems of Sewage Treatment: Led by E. H. Moss

Ohio Section—Scheduled Papers

Address of Welcome ..... Hon. Lee D. Schrog, Mayor
Water Supply at Akron ..... The Akron Boys
The Water Works Manager and His Community
R. W. Furman, C. E. Inman and T. B. Ray
Pipe Laying Up To Date ..... Philip Burgess
Recent Improvements in Cincinnati Water Works ..... Carl Eberling
Municipal Water Works as a Business ..... R. F. MacDowell

Is the Water Bill a Lien Against Property? ..... Ed. F. Alexander
Pumps for Small Water Works ..... C. C. Walker
Free Water ..... F. O. Wallene
Rehabilitation of Water Mains ..... Earl Hoyt
Discussion ..... J. M. Powell
Economy Through Office Management ..... M. F. Hoffman
Round Table Discussions: ..... Led by Philip Burgess
Troubles at Small Water Works ..... Ray Erion
Unusual Occurrences at Water Works ..... T. H. Larkins
Cold Weather Problems ..... R. S. Banks

Pacific Northwest Section—Scheduled Papers

Address of Welcome ..... Hon. Joseph Carson, Mayor
Round Table Discussions: ..... Led by Harold Fowler
Growths in Reservoirs ..... James Morrison
Testing Water Meters—Volumetric ..... Walter A. Wood
Testing Water Meters—Weight ..... A. H. Labsap
How Often Should Meters Be Tested?—Large Meters ..... John Krieger
How Often Should Meters Be Tested?—Small Meters ..... Wm. C. Pittam
The Advisability of Covered Reservoirs From a Military and Sanitary Standpoint ..... A. Lindsay
Gastro-Enteritis Outbreak Traced to Painting of Water Tank ..... M. S. Campbell
The Relation Between the Fire Department and the Water Department ..... Jay W. Stevens
The Willamette Valley Project in Its Relation to Water Supply ..... John C. Lee
The Portland Water System ..... Ben S. Morrow
Round Table Discussions: ..... Led by Walter Moore
The Elimination of Hazardous Practices in Water Works ..... R. F. McLean
Field Welding a 48-Inch Submerged Water Main ..... W. H. Powell
Ground Water Conservation and Utilization ..... Charles E. Stricklin
City of Lewiston Water Supply (Motion Picture) ..... William P. Hughes and W. H. Berkeley

Rocky Mountain Section—Scheduled Papers

Address of Welcome ..... Gov. Ralph L. Carr
Response and Chairman's Address ..... Burgis G. Coy
New Standards for Pipe, Pipe Linings, and Pipe Jointing Compounds and Coatings ..... D. D. Gross
Discussion by ..... H. G. Watson, Angus Slee, Frank Hill and L. C. Osborn
Water Plant Management ..... Bruce Bronson
Discussion by ..... H. C. McClintock, Frank Keenan, and K. E. Darling
Construction and Operation of Well Water Supplies ..... Edward E. Johnson
Discussion by ..... A. C. Harness, Geo. Blizzard and Carl C. Jones
Meters, Charges, etc. ..... Henry W. Krull
Discussion by ..... Wm. A. Peters and Chester A. Truman
Water-Tight Concrete ..... Wm. Cheek
Discussion by ..... Jack W. Davis
Coagulants Used in Water Treatment ..... O. J. Ripple
Discussion by ..... Del Porter, L. C. Osborn, Chas. Riddell and Frank Hill

Southeastern Section—Scheduled Papers

Southwest Section—Scheduled Papers

Radio Directed Water and Sewer Service .... K. F. Hoefle
Discussion by .... Cecil H. Harrison
Grand River Dam .... W. R. Holway
Use of Photographic Methods in Water System Records .... H. N. Masoner
Discussion by .... R. W. Hall
Summer Sprinkling Rates .... Lyle M. Burnham
Discussion by .... G. L. Fugate
Maintenance of Water Wells .... Clyde R. Harvill
The Use of Aerial Surveys in Water Systems .... Fred Q. Casler
Water in the Production Department of the Oil Industry .... Kenneth R. Teis
A Simple Method for Positive Location of Cross-Connections in Piping Systems
R. O. Dohe
Sanitary Sewer Charges in the Southwest .... E. L. Filby
State Control of Oil Pollution .... Ogden S. Jones
Maintenance of Sanitary Sewers—Equipment and Methods .... R. R. Cooke

Virginia Section—Scheduled Papers

A Report of the Principal Events of the 1940 Convention of the American Water Works Association in Kansas City .... Harry E. Jordan
Problems Encountered in the Operation of a Small Water Works .... E. R. Sharp
The Use of Hexametaphosphate for the Control of Corrosion and the Prevention of Scale Formation in Distribution Systems .... R. C. Bardwell
Behind the Water Tap (A Technicolor Movie) .... E. A. Sigworth
Chlorination and De-Chlorination .... M. C. Smith and H. E. Lordley
Property Records and Valuation .... Reeves Newsom
The New Law of Design for Cast-Iron Pipe .... John D. Capron
The Application of the New Cast-Iron Pipe Specifications
Arthur Roberts, Jr.
Address .... Norman J. Howard
The Protection of Elevated Storage Tanks .... H. E. Silcox
What is Meant by Back Siphonage? .... R. T. Homewood
Deep and Shallow Wells .... William M. McGill
Feeding Small Amounts of Chlorine or Other Chemicals .... R. C. Clements
Discussion by .... Alan A. Wood
Dese Bones Gwine Rise Agin .... R. W. Fitzgerald
What Size Meter Should Be Used on Services? .... D. R. Taylor

Western Pennsylvania Section—Scheduled Papers

Address of Welcome .... Hon. Charles M. Mayne, Mayor
Ground Waters for Public Water Supplies .... R. M. Leggette
Discussion by .... Harry C. Kneeland
Symposium on Operating Results of Water Softening Plants:
South Pittsburgh Water Co. Plant .... Florus R. Parrin
Borough of Tarentum, Pa., Plant .... Charles J. Baker
Borough of Ambridge, Pa., Plant .... Daniel E. Davis
Shaler Township, Pa., Plant .... E. C. Trax
Discussion .... Led by H. M. Olson
Symposium on Protective Treatment of Metal Water Works Structures:
Rustop System of Cathodic Protection .... E. H. Ingle
Metallizing .... Russell Forney
Metal Protective Paints .... B. A. Meacham

The Effect of Mill Scale Removal on Paint Life . . . . J. O. Jackson
Water Pollution Control as a National Problem . . . . Ralph E. Tarbett
The Relation of Waste Disposal to Western Pa. Water Supplies
Charles H. Young
The City of New Castle Water Company System . . . . B. F. Johnson
Organizing for Design and Construction of a Water Works System
William W. Brush
The Use and Abuse of Depreciation . . . . John H. Murdoch, Jr.
Break-Point Chlorination . . . . A. E. Griffin
Discussion by . . . . Samuel P. McBride, E. C. Goering and A. R. Todd

West Virginia Section—Scheduled Papers

Address of Welcome . . . . Mayor G. R. Seamonds
Address . . . . L. R. Howson
Huntington Flood Wall . . . . H. F. Falkner
Huntington Water System . . . . J. C. Edwards
Experiences With Taste and Odor:
Charleston . . . . Lawson Hayner
Catlettsburg (Kentucky) . . . . H. Cable Cramer
Arthurdale . . . . Edward Carroll
Experiences and Results at Indianapolis With Taste and Odor
Neil Kershaw
Proposed Water Supply for Beckley . . . . W. D. Kelley
Shatter-Proof Water Mains . . . . W. F. Horsch
Cathodic Protection of Steel Structures . . . . E. H. Ingle
Progress in Abatement of Stream Pollution from Steel Mill Wastes
W. W. Hodge
Super-Chlorination . . . . H. A. Faber
Discussion by . . . . A. R. Todd
Grounding Electric Circuits . . . . O. K. Coleman
Experiences with Polyphosphates:
At Nitro . . . . P. L. McLaughlin
At Berwind . . . . W. H. Davis
At Chesapeake and Ohio Railway Company . . . . H. B. Dale
Trouble Period:
High Iron Content . . . . Nickey Leshkow
Local Troubles and Remedies . . . . Kenneth Waldeck
Cleaning Wells at Parkersburg . . . . Golden Underwood
Handling Flood Water at Hinton . . . . M. H. Martin
Recent Pollution Studies of the State Water Commission . . . . K. S. Watson
Water Bacteriology . . . . E. A. Martens
Early Water Supplies in West Virginia . . . . H. K. Gidley

Wisconsin Section—Scheduled Papers

National Board Inspection Reports and Application in Fixing Insurance Rates
J. B. Wilkinson
Operation of Texas Insurance Commission . . . . Walter Staeffler
Relation Between Water Utility and the City Administration . . . . L. A. Smith
Behind the Water Tap (Motion Picture)
Construction and Operation of Antigo Iron Removal Plant . . Bruno J. Hartman

Construction of Addition to the Sheboygan Filter Plant (Motion Picture)
Jerome C. Zufelt
Construction of Elkhorn Iron Removal Plant (Motion Picture)
Neal B. Thayer
Construction of Racine's Service Building .... Walter Peirce
Round Table Discussion:
Meter Maintenance Practice .... Arthur Kuranz
Electrical Grounding of Water Mains .... Walter Peirce
Construction of Mains and Services .... Harold Lando
Station Records—
Experiments with Photo-Electric Cells .... J. J. McCarthy
What Water Softening Will Accomplish for Wisconsin Water Supplies
L. R. Howson
Break-Point Chlorination .... Cecil K. Calvert
Some Problems in Handling Activated Carbon .... James Kerslake
Back Siphonage in Cross-Connections (Illustrated by Motion Pictures)
William R. Brookman

Section Meetings—1940

Section	*Meeting Place*	*Date*
California	Los Angeles, Calif.	Oct. 23–26
Canadian	London, Ont., Canada	Mar. 27–29
Cuban	Havana, Cuba	May 21
	Havana, Cuba	Oct. 26
Florida	Jacksonville, Fla.	May 16–18
Four States	Wilmington, Del.	Nov. 7–8
Illinois	Chicago, Ill.	May 22–24
Indiana	Lafayette, Ind.	Apr. 4–5
Kentucky-Tennessee	Lexington, Ky.	Oct. 21–23
Michigan	Ann Arbor, Mich.	Sept. 11–13
Minnesota	St. Paul, Minn.	Nov. 7–9
Missouri Valley	Omaha, Neb.	Nov. 13–15
Montana	Miles City, Mont.	Apr. 5–6
New England	No scheduled meeting	—
New Jersey	New Brunswick, N. J.	Feb. 7
	Trenton, N. J.	May 22
	Atlantic City, N. J.	Oct. 18–19
New York	Ithaca, N. Y.	June 6–7
	New York, N. Y.	Sept. 25
	New York, N. Y.	Dec. 27
North Carolina	Raleigh, N. C.	Oct. 28–30
Ohio	Akron, Ohio	May 9–10
Pacific Northwest	Portland, Ore.	May 8–10
Rocky Mountain	Denver, Colo.	Sept. 16–18
Southeastern	Birmingham, Ala.	Mar. 18–20
Southwest	Tulsa, Okla.	Oct. 14–17
Virginia	Charlottesville, Va.	Sept. 5–6
Western Pennsylvania	New Castle, Pa.	Sept. 18–20
West Virginia	Huntington, W. Va.	Oct. 24–26
Wisconsin	Manitowoc, Wis.	Oct. 14–16

Section Membership at Time of and Total Attendance at Section Meetings, 1938–40

	1938		1939		1940	
	Membership	Attendance	Membership	Attendance	Membership	Attendance
California	440	1,007	470	1,035	501	1,082
Canadian	217	415	222	445	219	367
Cuban	*	—	*	—	27	†
Florida	52	82	63	110	76	134
Four States	174	129	191	150	186	177
Illinois	181	184	194	‡	199	226
Indiana	104	195	125	230	125	200
Kentucky-Tennessee	63	152	74	108	89	93
Michigan	88	192	99	218	116	233
Minnesota	48	156	69	115	77	169
Missouri Valley	146	208	175	¥	197	150
Montana	35	68	36	118	41	75
New England	127	†	131	†	137	†
New Jersey¶	174	150	205	136	218	172
New York§	461	‡	438	190	440	206
North Carolina	78	240	90	244	108	226
Ohio	*	—	139	136	163	198
Pacific Northwest	112	232	121	224	141	260
Rocky Mountain	74	95	79	131	87	123
Southeastern	134	¥	143	222	157	222
Southwest	121	300	121	422	202	297
Virginia	49	100	53	94	53	103
West Virginia	*	—	54	145	63	168
Western Pennsylvania	*	—	106	73	120	142
Wisconsin	72	233	73	258	76	238

* Section not organized.

† No regular meeting scheduled. Membership given as of date of general convention.

‡ No record of attendance.

¥ Regular meeting cancelled. Business meeting held at general convention.

¶ Three regular meetings held. Only fall meeting recorded here.

§ Three regular meetings held. Only spring meeting recorded here.

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Index of Abstract Topic Headings

ABSTRACTS

Abstract Subjects

For location of articles under general subject headings, see the Index of Topic Headings on page 2142. Specific items under those headings are contained in the following pages.

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